MOORE'S LAKE

Head of Bear River, Uintah Mountains

SUN PICTURES

OF

ROCKY MOUNTAIN SCENERY,

WITH A DESCRIPTION OF THE GEOGRAPHICAL AND GEOLOGICAL FEATURES, AND SOME ACCOUNT OF THE RESOURCES

OF THE

GREAT WEST;

CONTAINING THIRTY PHOTOGRAPHIC VIEWS ALONG THE LINE OF THE PACIFIC RAIL ROAD, FROM OMAHA TO SACRAMENTO,

BY

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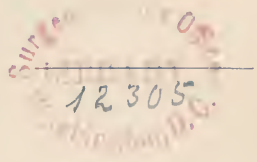

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INTRODUCTORY.

FOR several years past, during various expeditions to the territories west of the Mississippi River, I have earnestly desired to present to the world some of the remarkable scenery of the Rocky Mountain region, through the medium of photography, as the nearest approach to a truthful delineation of nature.

The construction of the Pacific Railroad led to the production of a large number of fine photographic views, taken by Mr. A. J. Russell, of New York, who spent more than two years along the line of the road in the employ of the Union Pacific Railroad Company. Thirty views have been chosen, and the preference has been given, in most cases, to those which illustrate some peculiar feature in the geology or geography of that interesting country. The pictures have been arranged so as to commence with the first range of mountains west of Cheyenne, and to continue thence to Salt Lake Valley, with the view, that the book may be used as a guide by those who will avail themselves of the grand opportunities for geological study, which a trip across the continent affords to every intelligent mind.

The increasing interest now taken in the science of geology, has led me to believe, that a volume embodying the principal geological facts in regard to a country, which has been and will be visited by so many thousands, would be read with interest.

Most of the material that constitutes the text covers entirely new ground, or has been published only to a limited extent. The photographs I have selected to illustrate the peculiar surface features, given

to the country by different geological formations. Thus, photographs II., III. and IV. exhibit the style of weathering peculiar to the granites of the first range of mountains; V., the Triassic sandstones; VI., is a mountain prairie view; VII., shows a distant view of one of the lofty ranges of mountains with the perpetual snow on its summits, while in the foreground the dense forests of pine and spruce are well brought out.

Two views from the Central Pacific Railroad (at the close of the book) afford the reader a glimpse of the wonderful scenery of the Sierra Nevada and the Pacific Coast.

In the general arrangement, it will be noted that I have in part followed the plan adopted by Professor J. D. Whitney in his most elegant "Yosemite Book," and although the scenery is by no means as grand and imposing along the Pacific Railroad, as that of the Yosemite Valley, it will be found to be more varied and equally as instructive.

I take pleasure in expressing my thanks to many kind friends for aid and sympathy in my undertaking, and especially to Messrs. Newberry, Cope, Scudder and Leidy, whose communications are of great value.

If this work meets with favor from the public, it may be followed at some future day by a selection of views of the country bordering the Central Pacific Railroad from Salt Lake Valley to San Francisco.

CHAPTER I.

GEOGRAPHICAL.

NEVER in the history of our country has the term "The Great West" possessed so much significance as at the present time. Thirty years ago, Ohio, Indiana and Illinois were called the far Western States, while but little was known of the vast regions beyond; now, farms and villages with sites of future cities are dotted over the plains and mountain slopes as they stretch westward toward the setting sun.

At the very threshold of our undertaking it is proper that we should make some inquiry into the extent and capacities of this great country, and into the physical causes which have produced its present configuration. If we look at any good geographical map we shall see at a glance that at least two-thirds of the United States of America, an area of more than two millions of square miles, lie west of the Mississippi River. In the part lying east of that river and containing less than half that area, now dwell between thirty and forty millions of people. The Atlantic Coast, with its crowded population, its refined civilization, its great cities, its seats of learning and industrial operations, forms only a fringe on the eastern border of this vast continent.

Prior to the travels of Lewis and Clark, in 1803 and 1804, across the northern portion of our continent, it was supposed that the Rocky Mountains consisted of a single ridge, or range, extending from north to south, or at least of one main range with a few minor ranges, and the old maps were constructed on that plan. Our present knowledge reveals to us the fact, that the name "Rocky Mountains" is only a general and rather indefinite term, including an almost limitless series of ranges of every possible variety of form. From the eastern slope westward, we pass over range after range for a thousand miles or more, until we descend the western slope of the Coast Range to the

Pacific Ocean. We shall find it, therefore, an interesting subject of study to inquire into the plan of growth or development of this vast region, and we believe that we have at the present time sufficient facts upon which to base some conclusions.

The great area west of the Mississippi seems to have been, at one time, an enormous plateau, out of which were evolved the different ranges of mountains, as if they had been thrust up by some volcanic force. Let the traveler pass southward, from Cheyenne to Denver, along the immediate base of the eastern range, and he will find that the mountains, of which the snow-covered summits of Pike's and Long's Peaks form a part, rise rather abruptly out of what appears to the eye an almost level prairie region, and will see the inclined ridges of the various sedimentary formations elevated to view, as if the huge granite masses had been thrust up, leaving upon their sides the sandstones and limestones of the more modern beds. These magnificent scenes at once fill the thoughtful mind with wonder and delight, and its first inquiry is as to the manner in which these stupendous changes have been brought about.

In general terms we may say, that the entire country west of the Mississippi may be divided into mountain and prairie. Suppose we proceed westward from Leavenworth or Omaha, we will find no large forests and very little timber, except that which skirts the small streams, until we reach the eastern base of the Rocky Mountains; it consists mostly of cotton wood; a few low oaks, however, are found on the dry hills, with here and there an elm or ash. The whole surface is undulating, ridge and hill, rising as far as the eye can reach, like the waves of the sea after a storm. This combination of mountain and prairie may be said to comprise what is generally known as the Rocky Mountain region. To understand more clearly the original plateau character of this region, we have only to examine the numerous barometrical profiles which have already been constructed across the continent. The explorations made several years ago under the direction of the War Department, and those more recently for the different lines of railroad, either built or in process of construction, afford ample means for its study to the traveler. If we proceed westward, from any point along the Missouri or Mississippi Rivers, we will find that the ascent is gradual, at first not more than one

foot per mile, but steadily increasing until we reach the base of the mountains, where the ascent is 50 to 100 feet per mile. If we examine the profile along the Kansas Pacific Railroad route, we find that Kansas City, on the Missouri River, is 637 feet above tide-water, and proceeding westward to Fort Riley, a distance of about 100 miles, we observe that the elevation has increased to 925 feet, an ascent of about two feet per mile. Three hundred miles farther westward the elevation is more than 3,000 feet, and so on until we reach the beautiful city of Denver, near the base of the mountains, where we shall have attained an elevation above tide-water, of 5,300 feet; we then come to the eastern ranges of the Rocky Mountains, which seem to rise abruptly out of the plains, some of the highest peaks of which reach an elevation of more than 14,000 feet above the level of the sea. Let us look at the excellent profile of the Union Pacific Railroad, constructed under the supervision of the eminent engineer, General G. M. Dodge. We find that Omaha is about 967 feet above the sea, while Columbus, 91 miles to the westward, is 1,455 feet, making a difference of 488 feet in the elevation, or an ascent of more than five feet to the mile. At Cheyenne, 517 miles west of Omaha, and located near the foot of the mountain range, the elevation is 6,072 feet. At Evan's Pass, the summit of the Black Hills, or first range, the elevation is 8,262 feet, so that in the short distance of 33 miles west of Cheyenne, we have a difference in elevation of 2,200 feet, or an ascending grade of nearly 70 feet to the mile. Again, let us for a moment examine the barometrical profile constructed by the late Governor I. I. Stevens for the Northern Pacific Railroad, near the north line of the United States; St. Paul, Minnesota, is about 828 feet above tide-water; near the mouth of the Yellow Stone River, 670 miles to the westward, we find that the elevation is 2,010 feet above the sea; there is a gradual and almost imperceptible ascent in that distance, of 1,172 feet, or an average of nearly two feet to the mile. As we approach the base of the mountains the ascending grade continues to increase, and when we have reached the valley of Dearborn River, at the immediate foot of the eastern slope, 448 miles farther west, we ascertain that this locality is 4,091 feet above the sea level, and that we have ascended 2,081 feet, or nearly five feet to the mile. Now, in traveling westward to each of the points mentioned, near the immediate

base of the mountains—Dearborn River, Cheyenne, and Denver—we find no important ranges of mountains, only country of the true typical prairie or plains. Then, as we proceed westward—as the profiles will show—we pass over range after range, among the most beautiful mountain valleys for 1,000 miles or more, until we descend almost abruptly, as it were, to the shores of the great Pacific Ocean. If we look at the map carefully we shall also see that there is a distinct line of separation between the sources of the waters that flow into the Pacific on the west side, and into the Atlantic on the east. This is called the divide of the great water shed of the continent; and however meandering it may be, it is always so well defined that it can be easily traced. We might continue these examinations in regard to the profiles to an almost unlimited extent (with similar results), but we have said enough to lay before our readers a glimpse of the beautiful plan of the physical growth of our continent.

We think that we have shown that the whole area west of the Mississippi may be regarded as a vast plateau, and that it was gradually elevated by forces operating in the interior of the earth, until the crust of the more central portions was strained to its utmost tension, and that then commenced those lines of fracture, of greater or less extent, along which the lofty ranges, which, taken collectively, now pass under the name of the Rocky Mountains, were slowly evolved. So far as my observations have extended—and they have been mostly confined to the eastern ranges—there appear to be two well marked types of mountain elevations, namely, those which have a granitic nucleus, and form long continuous lines of fracture with comparatively little inequality of outline, and those ranges which are composed of erupted rocks, and are very rugged in their outlines, and irregular in their trend. The Black Hills of Dakota, the most eastern outlier of the Rocky Mountains, present the finest illustration of the first type; the Laramie range (or Black Hills, as they are sometimes improperly called), near Cheyenne and the Big Horn range, are also excellent examples of the first; the Sierras, with their jagged saw-like irregular outlines, of the last type. It may not be out of place here to describe briefly some of the mountain ranges along the eastern slope, which, at no distant day, will attract the attention of the traveler, and will reveal to him some of the grandest, as well as the most beautiful forms of scenery in the world.

The time is not remote when it will be considered a want of education and good taste, that an American should have sought the Alpine Mountains of Central Europe for beautiful scenery, and neglected the far grander exhibitions of nature's handiwork in his own country.

As the multitudes of rivers that wind like arteries through the country and excavate the avenues for our railroads, have their sources in the mountain ranges, we ought at least to give them an honorable mention in this connection.

The Black Hills of Dakota are located between the 43d and 45th degrees of latitude, and 103d and 105th parallels of longitude, and occupy an area about 100 miles in length and 60 in breath. According to General Warren, the shape of the mass is elliptical, and the major axis trends about 20 degrees west of north. The base of these hills is from 2,500 to 3,000, and the highest peak 6,700 feet above the sea. The whole range is embraced by the forks of the Cheyenne River, called the north and south branches, which united, constitute the most important stream flowing into the Missouri River from the south side.

The north branch passes along the northern side of the range, receiving very many of its tributaries and most of its waters from it, but takes its rise far to the west of the range, near the source of Powder River, in the "divide" between the waters of the Yellowstone and those of the Missouri.

The south branch also rises in the same divide, flowing along the southern base of the range, and also receives numerous tributaries which have their sources in it. These two main branches unite about 30 miles east of the Black Hills, forming the Big Cheyenne, which empties into the Missouri, about 60 miles above Fort Pierre. The Moreau, Grand, Cannon Ball, and other rivers flowing into the Missouri north of the Cheyenne and south of the Yellowstone, rise in a high Tertiary divide north of the Black Hills, and are for the greater part of the season quite shallow and sometimes nearly dry, but the Little Missouri derives a portion of its waters from the Black Hills through a number of small branches which flow from the northwestern slope.

We thus see that the Black Hills do not give rise directly to any important stream, if we except the Little Missouri, a few branches of

which flow from springs near the base of the hills, affording but a comparatively small supply of water from that source.

We will allude for a moment to what we believe to be the economic value of the timber in the Black Hills to the people now rapidly settling the western territory. As we have previously remarked in this chapter, these hills occupy an area about 100 miles in length and about 60 in breadth, or 6,000 square miles. I think it is safe to say that at least one-third of this area, or about 2,000 square miles, or 1,280,000 acres, is covered with excellent pine timber. The question arises, how is this timber to be made available? As before stated, the two forks of the Cheyenne River, as it were, clasp the Black Hills, the two branches passing along close to their northern and southern borders. At least from four to six months of the year these streams are quite high. The logs could be cut and taken to the sides of these streams during the dry season, and when the waters are high in the spring of the year they could be taken down into the Missouri River safely and without much difficulty. At least, that is my impression. In a report made to General G. K. Warren, March 15, 1856, I made use of the following language: "The Black Hills which appear in the distance, and derive their name from their dark and gloomy appearance, contain an inexhaustible quantity of the finest timber, mostly pine, which will doubtless remain undisturbed for many years to come. I will, however, propose a plan for obtaining this timber and rendering it useful to future settlers; though I do it with some hesitation, lest it may seem visionary. The left fork of the Cheyenne passes through the northern portion of the Black Hills, and is even there a considerable stream, from 30 to 50 yards wide. In the spring the river is much swollen, and the current exceedingly rapid, and the timber, if cut and hauled to the banks of the river, might be floated down into the Missouri with considerable safety and ease." At the time the above was written I had seen but little of the Black Hills, and nothing was known of the geography of the forks of the Cheyenne.

The geological structure of the Black Hills may be briefly mentioned here. The nucleus or the central portion is composed of red feldspathic granite, with a series of metamorphic slates and schists superimposed, and thence upon each side of the axis of elevation the various fossiliferous

formations of this region follow in their order to the summits of the Cretaceous, the whole inclining against the granitoid rocks at a greater or less angle. There seems to be no unconformability in the fossiliferous rocks, from the Potsdam inclusive to the top of the Cretaceous. From these facts we draw the inference that, prior to the elevation of the Black Hills, which must have occurred after the deposition of the Cretaceous rocks, all these formations presented an unbroken continuity over the whole area occupied by these mountains. This is an important conclusion, and we shall hereafter see its application to other ranges, and also to the Rocky Mountain range taken in the aggregate.

Proceeding in a southwest direction from the Black Hills, we find that there are ample proofs of the connection of these hills with the Laramie Mountains through a low anti-clinal which can be followed for many miles. It is sometimes concealed by the recent tertiary beds, but it reappears at different points. By the Laramie Mountains we designate that group of ranges which extends from the Red Buttes southward to the Arkansas. This group, when examined in detail, is composed of a large number of smaller ranges, all, as far as I have observed, of the true granitic type. The trend of the whole group is very nearly north and south, northward as far as Fort Laramie, where it makes an abrupt flexure around to the west and northwest, and gradually ceases or dies out at the Red Buttes. From this point, westward and northward, there is a space from 20 to 40 miles in width destitute of mountain elevations, though the strata exhibit evidences of dislocation or crust movements.

The Laramie range is also composed geologically of a granitoid nucleus, with the fossiliferous formations, Silurian, Carboniferous, Red arenaceous beds (Triassic), Jurassic, Cretaceous, and in many places Lignite Tertiary, inclining from each side of a central axis at various angles. It is from these mountains that the numerous branches of the Platte have their sources, extending a distance of nearly 400 miles. From the observations which I have made in this range, it seems to me the conclusion is plain, that all the above-named rocks, in a nearly or quite horizontal position, were some time during the Tertiary period, continuous over the whole area occupied by them at the present time.

The most important outlier of the Rocky Mountains, on the eastern slope, is the Big Horn range, which, though somewhat irregular in the shape of its mass, has a general trend nearly northwest and south-

east. It occupies an area about 100 miles in length and 50 in breadth. Near latitude 43½° and longitude 102° the line of fracture seems to have partially died out toward the south and southeast, and to have made a gradual flexure around to the west, the whole range soon losing its granitoid character, and becoming entirely composed of more modern eruptive rocks. The eruptive portion continues westward until it joins the Wind River range, near the sources of Wind River.

At the southern end of the Big Horn Mountains we can trace a single low anti-clinal across the prairie connecting these mountains with the Laramie range at the Red Buttes, on the North Platte. We farther know, by the position of the sedimentary beds upheaved along the mountains, that these mountains also form a connection with the Wind River range by the gradual flexure westward of the eruptive rocks. The central portion of these mountains is also composed of granite and granitoid rocks, with the same series of fossiliferous formations, inclining at various angles from each side of the axis of elevation, as is seen around the Black Hills and along the Laramie Mountains. Some of the more lofty peaks are from 8,000 to 12,000 feet above the sea, and are covered with perpetual snow. We think that the evidence is quite conclusive that, up to the time of the accumulation of a large portion of the Lignite Tertiary beds, all these formations, from the Silurian to the true Lignite strata, inclusive, were in a horizontal position, extending continuously over the whole area occupied by the mountains; but as they were slowly elevated, the central portions were removed by the erosive action of water. The eruptive portion which unites the Big Horn range with the Wind River Mountains is exceedingly picturesque, presenting the appearance of a connected series of basaltic cones, but is so rugged and inaccessible, that even the persevering trappers have never been able to penetrate it in their hunting explorations.

Like the Black Hills, the Big Horn range does not give rise to any important sub-hydrographical basins. The largest stream in this region, and one which gives name to the mountains, rises in the Wind River range, passes through the Big Horn Mountains, and unites with the Yellowstone about 70 miles to the northward. Before reaching the mountains it takes the name of Wind River, and assumes the name of Big Horn after emerging from them. This range, however, constitutes

quite an important feeder to the Yellowstone. Powder River, which rises in this range by numerous branches, drains a large area, mostly Lignite Tertiary, and pours a considerable volume of water into the Yellowstone, near longitude 105½° and latitude 46½°. Tongue River is the next most important stream, which, though not draining so great an area as Powder River, empties into the Yellowstone a much larger volume of water.

The Medicine Bow and Sweetwater Mountains appear to be of the same character, for the most part; but on the east side of the Sweetwater River, the evidence of igneous action is shown on a large scale. The ancient volcanic material would seem to have been elevated to a great height in but a partially fluid condition, and then to have gradually cooled, affecting to a greater or less extent the fossiliferous strata in contact.

Near the junction of the Popo Agie with Wind River, we come in full view of the Wind River Mountains, which form the dividing crest of the continent, the streams on the one side flowing into the Atlantic, and those on the other into the Pacific. This range is also composed, to a large extent, of red and gray feldspathic granite, with the fossiliferous rocks inclining high upon its sides. After passing the sources of Wind River, the mountains appear to be composed entirely of eruptive rocks. Even the Three Tetons, which raise their summits 11,000 feet above the ocean level, are formed of very compact basaltic rock. The Wasatch and Green River ranges, where we observed them, have the same igneous origin, and the mountains all along the sources of the different branches of the Columbia exhibit these rocks in their full force. In Pierre's Hole, Jackson's Hole, and other valleys surrounded by upheaved ridges, these ancient volcanic rocks seem to have been poured over the country, and to have cooled in layers, giving to vast thicknesses of the rocks the appearance of stratified beds.

The mountains about the sources of the Missouri and Yellowstone Rivers are of eruptive origin, and in the valley of the Madison fork of the Missouri are vertical walls of these ancient volcanic rocks 1,000 to 1,500 feet in height, exhibiting the appearance of stratified deposits, dipping at a considerable angle. As we pass down the Madison we find some beds of feldspathic rocks, and mica and clay slates beneath the eruptive layers, dipping at the same angle. After passing the divide

below the Three Forks of the Missouri, we see a number of partially detached ranges, which appear to possess the same igneous character. In the Belt, the Highwood Mountains, and indeed all along the eastern slope in this region, we find continual evidence of the outpouring of the melted material in the form of surface beds or thin layers, thrust between the fossiliferous strata. These igneous beds thin out rapidly, as we recede from the point of effusion. A large number of these centres of protrusion may be seen along the slope of the mountains west of the Judith range. The eruptive material sometimes presents a vertical wall 300 feet high, then suddenly thins out and disappears. The Judith, Bear's Paw, and Little Rocky Mountains seem to be composed for the most part of granite and other rocks, with igneous protrusions here and there. I had supposed, from the observations made in my former explorations, that the central portions of our mountain ranges were composed of feldspathic granite, and to a certain extent this is true of the most eastern outliers, but my examinations during a later expedition have convinced me that these rocks, which I have classed as eruptive, compose by far the greater portion of the mountain masses of the west.

In this connection I have thought it best to present a brief and systematic account of the principal rivers that drain this immense area of country. The Missouri River and its tributaries form one of the largest as well as most important hydrographical basins in America. They drain an area of nearly or quite one million square miles. Rising in the loftiest portion of the Rocky Mountains, near latitude 44°, longitude 113°, the Missouri flows northward in three principal branches, Madison, Gallatin, and Jefferson Forks, to their junction, and then proceeds onward until it emerges from the gate of the mountains, a distance of nearly 200 miles; it then bends to the eastward, flowing in this direction to the entrance of White Earth River, a distance of nearly 500 miles; it then gradually bends southward and southeastward to its junction with the Mississippi, a distance of 1,500 to 2,000 miles. The branches which form the sources of the Missouri rise in the central portions of the Rocky Mountain range, flowing through granitic, basaltic, and the older sedimentary rocks until it emerges from the gate of the mountains, when the Triassic and Jurassic beds are shown. The falls of the Missouri, extending for a distance of 20 or 30 miles, cut their way through a great thickness of compact Triassic rocks. Below the falls, the channel makes its way through the soft yielding clays

and sands of the Cretaceous beds for about 250 miles, with the exception of the Judith Tertiary basin, which is about 40 miles in length. The Cretaceous beds then reappear, extending nearly to the mouth of the Milk River, where the Lignite Tertiary formations commence. These are also composed of sands, marls and clays, as the character of the valley will show. The river flows through these Tertiary beds to the mouth of Heart River below Fort Union, a distance of nearly 250 miles, where the Cretaceous rocks come to the surface again. These latter rocks extend to within a short distance of Council Bluffs, more than 500 miles. I have estimated the distances in a straight line as nearly as possible. Just above Council Bluffs the coal measure limestones commence, and the valley of the Missouri gradually becomes more restricted, though it is still of moderate width below the mouth of the Kansas.

The Yellowstone River is by far the largest branch of the Missouri, and for 400 miles, from its mouth up, it seems to be as large as the Missouri itself from Fort Union to Fort Pierre. It is navigable for large steamers during the spring and early summer for 300 or 400 miles above its junction with the Missouri. This river also takes its rise in the main divide of the Rocky Mountains, near latitude 44½° and longitude 110°, as some suppose, in a lake, called Yellowstone Lake, which is about 60 miles long and 10 to 20 wide. Its channel is formed in rocks similar to those of the Missouri, about 400 miles of its course passing through Lignite Tertiary beds. The character of its valley is very similar to that of the Missouri. Most of the important branches of this river I have alluded to in the preceding portion of this chapter. Tongue and Powder Rivers, which are quite long branches, have their origin in the Big Horn Mountains, their channels cutting through the different rocks that surround the Big Horn range. Tongue River is nearly 150 miles in length, and flows for the most part through the soft yielding rocks of the Lignite Tertiary. Powder River is from 250 to 300 miles in length, and also flows nearly all its course through the same Tertiary beds.

Passing below Fort Union we observe on the right side of the Missouri River several large rivers, as Little Missouri, Big Knife, Heart, Cannon Ball, Grand, Moreau, and Big Cheyenne. The Little Missouri receives a small portion of its waters from the Black Hills, but most of its branches have their origin in the prairie. The Big Cheyenne, though receiving most of its waters from the Black Hills, takes its rise far

west of them in the Tertiary beds, but after flowing past the Black Hills wears its channel through the upper Cretaceous beds. The other rivers mentioned take their rise in the Lignite Tertiary beds, near the eastern base of the Black Hills, and flow through these Tertiary strata until very near or quite to their junction with the Missouri.

The Teton River takes its origin in the northwestern rim of the White River Tertiary, runs nearly east, for the most part through formations of the upper Cretaceous period. It drains an area about 100 miles in length and 30 to 50 miles in width. The next most prominent stream is White River, which flows directly through the Bad Lands, and gives the name to one of the most remarkable Tertiary deposits in the world. It takes its rise in the prairie near latitude 42½° and longitude 104°, flows for a time in a northeast direction, then bends so as to enter the Missouri a little south of east near latitude 43° 41′ and longitude 99½°. Nearly its entire course is through the White River Tertiary beds, and for the greater part of the year its waters are so full of sediment that they are unfit for use. When they stand for a time a thick scum accumulates on the surface which has much the color and consistency of cream. The water itself looks very much like turbid lime-water and is very astringent to the taste. The valley is generally open, tolerably well wooded, abounding in fine grass, and has always been a favorite resort for the Indians. The road between Forts Laramie and Pierre passes along the valley for a considerable distance, through some of the most picturesque scenery in the West. The river has numerous branches, but the only one of importance is called the South Fork, and is nearly as large and long as the main stream. It drains an area about 250 miles in length and 40 to 60 in breadth.

The Niobrara is the next most important stream, and as the area drained by this river has been the subject of much interest to the inhabitants of Nebraska and Dakota, I take the liberty of quoting the minute and excellent description of General Warren: "The Niobrara being a stream heretofore unknown, and one in which the people of Nebraska feel much interest, I shall describe it in detail. The river is about 450 miles long. From its source to longitude 103° 15′, it is a beautiful little stream of running water, of a width of from 10 to 15 feet, gradually widening as it descends. Its valley furnishes here very good grass, abounding in rushes or prêle, but it is for the most part destitute of

wood even for cooking. After flowing thus far it rapidly widens; till in longitude 102° 30′, it attains a width of 60 to 80 yards; its valley is still quite open and easy to travel along, but destitute of wood except occasional pines on the distant hills to the north. In longitude 102° 30′ it enters between high steep banks which closely confine it, and for a long way it is a complete cañon; here, however, wood becomes more abundant and pine is occasionally seen on the bluffs, while small clusters of cotton wood, elm and ash occupy the narrow points left by its windings. In longitude 101° 45′ the sand hills come on the north side close to the river, while on the south side they are at a distance of from one to two miles off, leaving a smooth road to travel all along the bluffs. The bluffs gradually appear higher and higher above the stream as it descends until they reach the height of 300 feet. The sand mostly ceases on the north side in longitude 100° 23′; but it lies close to the stream on the south side nearly all the way to Wasikonska. Throughout this section lying between longitude 102° 00′ and longitude 99° 20′, a distance of 180 miles, the Niobrara is in every respect a peculiar stream, and there is none that I know of that it can be compared with. It flows here between high rocky banks of soft white and yellowish calcareous and siliceous sandstone, standing often in precipices at the water's edge, its verticality being preserved by a capping of hard grit. It is here impossible to travel any considerable distance along its immediate banks without having frequently to climb the ridges which rise sometimes perpendicularly from the stream. As you approach from the north or south there are no indications of a river till you come within two or three miles of the banks, and then only by the trees, whose tops occasionally rise above the ravines in which they grow, so completely is it walled in by high bluffs which enclose its narrow valley. It seems to have resulted from a fissure in the earth's crust, and now flows at a depth of about 300 feet below the general level of the prairie. The soft rock which forms the bluffs is worn into the most intricate labyrinths by the little streams, all of which have their sources in beautiful gushing springs of clear cold water. In these small deep valleys the grass is luxuriant; pine, ash, and oak are abundant; cherries, currants, gooseberries, plums and grapes grow in profusion in their season. Elk, deer, and other animals find here their choicest haunts, and here they congregate during the snows and cold of winter. The region is a perfect paradise for savage life, and the Brulés who now

have possession of it, probably value it as highly as ever human being did a home. Their indignation was great at our intrusion among them, and they were earnest in declaring that white men should never dispossess them while they lived. To the agriculturist this section has, however, comparatively little attraction, and that between longitude 99° 20′ and the mouth, an extent of about 90 miles, is perhaps far more valuable. Here the bottoms will probably average a width of a quarter of a mile, are susceptible of cultivation, and cotton wood, oak, walnut, and ash will furnish settlements with all the timber and fuel they will need. The river banks seem to present no good building stone, nor did we, though searching diligently, discover any signs of valuable coal or other minerals.

"In describing the tributaries to the Niobrara, I shall begin at the mouth and take the north side first. The Ponka River which has a very fine, well-wooded, and fertile valley runs into the Missouri about five miles north of the Niobrara, in latitude 42° 48′ north. Its course is parallel and near to that of the Niobrara, as far up as the mouth of Turtle Hill River, (Keha Paha) which is the main branch of the Niobrara, and is about 120 miles long. I crossed it in 1855, 60 miles above its mouth, and it has a very fine valley, one-half to three-fourths of a mile wide, with good soil and a limited quantity of fine cotton wood timber. The bed of the stream is sandy, and its waters are clear and sweet; width at the mouth 50 yards. The first 20 miles of the space between this branch and the main river is occupied by sand hills.

"The next northern branch which joins the Niobrara, longitude 100° 23′, is named Mini-cha-duza-Wakpa, or Rapid Creek. At its mouth it is about eight yards wide, with a valley from one-fourth to one-half mile wide, and a soil quite fertile, the banks being scantily fringed with small trees. It forms about the eastern border of the Sand Hills on the north side of the Niobrara, as far as we could see. Its length is about 50 miles.

"The mouth of the next stream is in longitude 101° 18′; it has scarcely any appreciable valley, flows between high rocky bluffs difficult to ascend and descend, is about five yards wide, with clear, deep, swift-running water, and is probably 35 miles long.

"The mouth of the next northern tributary, called White Earth Creek, is in longitude 101° 30′; it is about three-fourths the size of Rapid Creek, which it resembles in every particular, and is about 25 miles long.

The next, in longitude 102°, is a small spring rivulet about 26 miles long, and above this the branches are all small runs coming from the bluffs, generally dry except after rains, with no valley worthy of mention.

"On the south side of the Niobrara there are numerous small branches coming in between its junction with the Missouri and the point where it receives the waters of the Turtle Hill River. Three of these are of considerable size, probably 35 miles long, the bluffs along nearly all of them being more or less covered with scattered pine, and their valleys occupied with clumps of cotton wood, oak, ash, etc.

"From the mouth of Turtle Hill River to that of the Wazihonska there are a still greater number of short southern branches, all containing springs of water and abounding in pine and beautiful oak groves.

"Wazihonska means in Dakota tongue 'the place where the pine extends far out;' and this stream, whose mouth is in longitude 100°, is probably 40 miles long, and all its bluffs and side ravines are green with pine. Its valley, though not so wide, is very similar to that of the Niobrara in this part, which has been described.

"Snake River, the mouth of which is in longitude 100° 45′, is quite a large stream, some 30 yards wide, its bluffs covered with pine, and like the Wazihonska has a narrow valley.

"Above this there is scarcely any branch coming in from the south deserving mention.

"Niobrara is a very shallow and 'swift flowing stream,' as the Canadians say, *L'eau qui court*, abounding in rapids in two-thirds of its upper course, and in its middle portion filled with small islands. In the lower portion its width exceeds that of the Missouri River, and it is spread out over sand bars. The bed in the broad portions is quicksand and difficult to ford. Its waters rapidly increase in volume through its middle portion, from the multitude of springs and streamlets that constantly flow into it from the foot of the bluffs and out of the ravines. It furnishes no navigation, except it might be for light flatboats during floods, though probably it could be used for rafting. Logs could be driven if the timber should be found of a quality, quantity and accessibility to defray the expenses. I cannot, however, look upon it as capable of furnishing timber for the country on the Missouri, for the reason that much of the pine is too small, crooked, and knotty, growing in places from which it is too difficult to transport it. The species is what is called the Rocky Mountain

pine, has a yellowish white appearance, and abounds in resin. The distance on the Niobrara over which these pine ravines extend is about 120 miles.

"A road could not be made on the bottom lands of the Niobrara; it must keep out on the high prairie so as to head the ravines. From the mouth to Turtle Hill River it would take the narrow divide between the Niobrara and Ponka Rivers. It should continue on the north side of Turtle Hill River from 20 to 30 miles further, and then cross that stream, as it would thus avoid the sand at the junction of the Niobrara and Turtle Hill Rivers, and cross the latter where there is a better ford or narrower stream to bridge. Turning then toward the Niobrara, this river must be crossed in longitude 102° 20′ to avoid the sand hills, and the route must continue on the south side to about longitude 102°, when it should again cross to the north side. These crossings for a wagon road could easily be made at a ford or by bridging, but a proper bridge for a railroad crossing at these places would be a stupendous undertaking; for, on account of the nature of the banks and ravines, good approaches could not be found so as to descend to the level of the stream, and the bridge would need to be built very high. From longitude 102° west there are no difficulties, beyond a scarcity of wood, in reaching Fort Laramie, or in continuing direct to the South Pass, and in this course abundance of excellent pine would be found near Rawhide Peak.

"A preferable road might be found by continuing up Turtle Hill River to its source, and then along the divide between Niobrara and White Rivers, striking the former stream in longitude 103°; but these divides are generally bad for wagon routes on account of scarcity of water, and it is not certain that we would by that route avoid the sand hills.

"*White River*, or White Earth River (Mankisita Wakpa or Smoking Earth River), is a more beautiful stream than the Niobrara, having generally an open, well-wooded valley, with a fine soil and luxuriant grass. The road between Forts Laramie and Pierre follows the valley from its source to the Bad Lands, where the river enters a different section bounded with precipices like the Niobrara, but this is of much less extent. Any one who travels in Nebraska, will always feel rejoiced when he reaches the banks of this beautiful stream. It has numerous small branches, the largest of which is called the South Fork. The pine on White River and its tributaries is nearly equal in extent to that on the Niobrara."

The next sub-hydrographical basin, and perhaps in many respects the most important one in the Missouri valley, is that of the Platte, which empties into the Missouri River near latitude 41° 3′ 24″. Its valley forms a natural grade for a railroad to the foot of the mountains, and already one has been constructed from Omaha City across the continent.

The Platte River takes its rise in the Laramie range, and flows for the greater part of its course through the more recent beds of the Tertiary deposits. The area drained by this river must be at least 600 miles from east to west, and 80 to 150 from north to south. Although this stream is 1,000 yards or more wide, the water is so shallow and the channel so shifting that it can never be rendered navigable even for Mackinaw boats. Even the fur traders have never been able to rely on it for the transportation of their peltries, furs, and skins.

On the left or north side of the Missouri there are comparatively few branches; the principal of these are Milk, White Earth, James, Vermillion, and Big Sioux. The three last named rise in the far north and flow through a much more rocky region and over a stony bed, and their waters, as they pour into the Missouri, contain less sediment than any of the others. Indeed, most of the rivers previously described flow through a generally barren country, with a thirsty atmosphere and a still more thirsty soil, and on their way to the Missouri valley they lose nearly or quite all their waters. Many of these long rivers, as Grand, Cannon Ball and Cheyenne, in the autumn frequently have so little water as to cease to be running streams, while perhaps 100 miles above their mouths, if in the vicinity of some mountain, there is a full supply of water. The Mussel-Shell River is a fine example; toward its source it is a fine running stream; in the dry season it is lost almost entirely before reaching the Missouri. Much more might be said in this connection, but enough has been written to enable the reader to comprehend to some extent the geographical area drained by the Missouri River and its tributaries.

CHAPTER II.

OMAHA TO CHEYENNE, PLATTE VALLEY.

NOW that we have, in as brief terms as possible, constructed our mountain and river system, I shall ask the reader to travel with me along the line of the Union Pacific Railroad, wandering aside here and there, to cull a flower or examine an Indian village or read some wonderful legend which attaches to almost every portion of this country. We shall also delay now and then, to study the rocks and unearth their fossil contents; and in many a locality we shall find the poet's utterance no fiction, that there are "sermons in stones" etc. Scenes more wonderful than any related in the far-famed Arabian Nights' Entertainments have been performed on these apparently lifeless, monotonous plains. We may also take a look at some of nature's grand old ruins, which are infinitely more remarkable than those which have been hidden for centuries in the tangled and almost impenetrable forests of Central America. We may wind our labyrinthine way through cemeteries, the slumbering inhabitants of which, hundreds of thousands of years ago, roamed over these plains, before even pre-historic man had an existence, and long, long before the boasted civilization of Egypt and India had began; long before any form of expression was given to human history. And, too, over these almost limitless plains, which now seem to the eye as level as the quiet sea, and as treeless as the desert, we may wander in imagination through the luxuriant groves of forest trees, rivaling those of Central America or Brazil, which at no distant geological period covered all this vast region. In these, our imaginary wanderings into the past, we may take our selection from a dozen varieties of horses for our riding

animals, or we may make the gentle dromedary kneel to receive his burden; we may hunt the elephant and the mastodon in the jungle or watch the fierce battles between the gigantic elephant and the rhinoceros, which seem to have been abundant here. We may also note the bloody conflicts between the huge Hyænodon and the cat-like Machairodus as they roamed along the valleys of the little streams or the borders of the Tertiary lakes in search of the gregarious deer-like Oreodon. To the inquiring mind it will be seen that no portion of the world presents more topics of absorbing interest than the great Missouri Valley.

We shall commence our travels at Omaha, although none of the illustrations of the wonderful scenery of the West, which it is the object of this book to present, will be noticed until we come to the Rocky Mountains proper. Sixty-six years ago, a small but adventurous party under the guidance of two of the most eminent explorers of modern times, winding their slow and tedious way up the swift current of the Missouri, delayed for a time to rest and take astronomical observations near the mouth of the Platte River. Though thoroughly imbued with the prophetic insight of the projector of the expedition, they little dreamed of the splendid vista of greatness and prosperity their labors were going to open to the world. Those beautiful plains, where Bellevue, Omaha, and Council Bluffs are now located, were occupied by tribes of Indians that are now extinct, or have dwindled into insignificance. These tribes, with the still wilder animals, then held undisputed possession of all that country. Looking back along the past, a little more than half a century, it seems but a short period, yet what stupendous strides of progress have been made since then. Nearly all the vast area west of Ohio was a comparatively unknown territory; St. Louis was but a small rendezvous for fur traders, and the magic city of Chicago had then no existence. Now the Missouri and Mississippi Valleys are lined with prosperous villages and cities, and soon the balance of power will pass from the East to the West. Omaha tends to perpetuate the name of the tribe of Indians now fast passing away, which once owned all this region. The remnants of the tribe reside on their reservation near Blackbird Hill, 60 miles up the Missouri. Council Bluffs, on the opposite side of the Missouri, is a city continually growing in importance, and is a rival to Omaha. It derives its name from a group of hills, so called by Lewis and Clark, who held a council there on the 3d of August, 1804,

with the Otoes and Missouris. The latter tribe, though it has given the name to one of the largest rivers on the globe, and one of the richest States of the Union, is become extinct. Although the expedition of Lewis and Clark, in 1804–5 and 6, may be justly regarded as one of the most important achievements in exploration within the past century in any part of the world, and the two volumes of their report which they gave to the public, having very properly passed into the domain of history, may still be regarded as a model; and, although the second expedition under the command of Major Stephen H. Long, in 1819–20, was a complete success and most fruitful of results, yet it was left to the discovery of gold in California and Colorado, to open all this vast domain and move the tide of empire westward. The last great event which seems to have given the final impulse to this westward movement, was the construction and opening of the great Pacific Railroad. Omaha has the honor of being the eastern terminus of this important work. Soon the Missouri will be spanned by a bridge of gigantic dimensions, and then there will be an unbroken line of railway connection between New York and San Francisco.

As the traveler comes from the crowded cities of the old world, and looks on our eastern shores that are dotted over with cities with all the signs of civilization, he proceeds westward to Omaha with the expectation of finding a wild and almost uninhabited region. He comes armed to the teeth, ready to resist the attacks of the red man or to pursue the buffalo and the deer over the prairies, but he finds, to his surprise, one of the most thriving cities of the West, with all the conveniences and many of the luxuries that he supposed he had left behind in the more favored Eastern cities. He sees fine streets, walled on each side with massive, costly structures, and men running to and fro, full of enterprise and hope, where, fifteen years ago, the wandering savage pitched his tent.

The city of Omaha is most beautifully located on the western bank of the Missouri River, on a second terrace, about 50 feet above the water level of the river. Terraces of the kind alluded to form a peculiar feature along the Missouri River and its tributaries, and are found from the foot of the mountains to its mouth, and in many instances they seem to afford most beautiful natural sites for cities. I will not, at this time, enter into an explanation of the causes which produced these terraces, but simply remark that they indicate oscillations of level in the surface, and that,

far back in the past, each one of them has at one time formed the bed of the river. They also seem to indicate, that formerly the Missouri carried to the ocean a vastly greater volume of water than at present. Another feature will at once catch the eye of the observing traveler, and that is the marvelous fertility of all this region. The wide grassy bottoms are black with rich vegetable matter to an almost indefinite depth, while the upland terraces and hills are covered with a deposit of yellow marl, varying from 20 to 150 feet in thickness. There seems to be evidence that the ocean once extended up the valley of the Mississippi, and up the Missouri nearly to Fort Pierre, and that the myriads of mountain streams poured their fresh waters into this great arm of the sea, or estuary. These numerous streams, flowing through the soft marls, sands, and clays of the great plain country, mingled their sediments in the waters, and deposited them in the bottom of this estuary. The channels of all the larger rivers had been marked out prior to this time, for we find that these superficial deposits reach their greatest thickness in the immediate valley of the Missouri River and thin out as we pass up the valleys of its tributaries on the east and west side, while they almost cease to appear near the mouth of White Earth River.

The question at once occurs, at what time did this geographical condition of the country exist? We believe, that it forms a part of what is called the quarternary period in geology, which, though very modern, geologically speaking, really extended far back in the past before the existence of man on this continent, judging from the evidence we have been able to secure up to the present time. If we examine the numerous cuts, or washed bluffs, which we find everywhere, we shall discover a great variety of fresh-water and land shells, as Helices, Paludinas, Succinneas, etc., and here and there the remains of the mastodon and elephant. In the year 1867, while prosecuting the geological survey of Nebraska, under the General Government, I obtained from these marls fine specimens of the molar teeth of the *Elephas Americanus* or American elephant, and the mastodon, *M. Americanus*. These remains of gigantic extinct animals are mingled with those of animals existing in this region at the present time, such as rabbits, mice, gophers, beavers, buffalos, deer, etc., which have been found in great quantities. Nearly all the shells are identical with living species which are abundant in some of the streams flowing in to the Missouri and the Mississippi. In the banks of some of the

little streams, oftentimes buried 10 to 20 feet beneath the surface, are large accumulations of shells, as snails, fresh-water mussels, etc., while very few, and perhaps none exist at the present time in the immediate vicinity. Sometimes, in the fine vegetable matter that accumulates along the Missouri River from the annual floods, can be seen bushels of minute snail shells, yet not a snail can now be found alive anywhere in that region. We account for this by some change in the physical conditions which were once very favorable for their existence and increase. The waters of the little streams were far clearer and purer than at present. Now, at certain seasons of the year, they become so charged with sediment that molluscous life cannot exist. This is the case with the Missouri River, from the foot of the mountains to its mouth, and scarcely a shell can be found in its waters; but in some of its tributaries, as the Big Sioux, James, Vermillion, etc., that flow in from the north, there is the greatest abundance.

The traveler will very naturally inquire, why, with all this wonderful fertility of soil, these broad grass-covered plains do not contain a suitable supply of forest trees. We will endeavor to answer this question in another place. He will find, as he travels over the State of Nebraska, that the time is not very distant when portions of the country will be covered with beautiful artificial forests, and we will attempt to show that this is only a restoration of conditions that once existed far in the geological past.

While we delay for a time at the pleasant city of Omaha, and enjoy the generous hospitality of its citizens, we might make a short journey up the valley of the Missouri and take a glance at the more northern portions of the State. We shall find the climate more severe as we go northward, hardly adapted to the raising of the more delicate varieties of fruit, but that inexhaustible fertility of soil which we have so often alluded to, never fails. Far broader bottoms are spread out to the eye than are seen anywhere else in the West, varying from 5 to 39 miles in width, perfectly level and dotted here and there with groves of cotton wood; villages and farm houses meet the eye on every side, fields of wheat and corn of unusual luxuriance wave in the breeze, and the broad meadows are covered with a thick growth of coarse grass, so high as oftentimes to conceal the horse and his rider. Formerly, as the autumnal fires swept over the broad savannas, woe to the unfortunate being, man or animal, that was caught in their course. Herds of cattle and horses fled in consternation before the crack-

ling flames and dense smoke, and not unfrequently human beings were overtaken and consumed. Since the settlement of the country these fires have become far less common, but when they do occur, they are much more destructive than formerly, now frequently destroying the results of the hard labors of the farmer for an entire season; stacks of wheat and hay disappear like clouds before the wind. Many of the remarkable sights, which in former times were so common, are less frequent now, and the grand but terrific scene of a prairie on fire is for the most part a legend of the past. This broad Missouri Valley is walled by bluffs 600 to 800 feet high, and if we ascend one of them, there is nothing to obstruct the vision until the sky comes close down to meet the earth on either side. The great purity of the atmosphere enables one to see objects with wonderful clearness over large intervals of space, and, in consequence of this, most amusing instances of deception often occur in the estimate of distances. As an illustration of this fact I copy an extract from my journal of a voyage up the Missouri River in the American Fur Company's steamer in the summer of 1854:

"The first prairie of importance we come to on the Nebraska side is about 80 miles above Bellevue. Some of the machinery of the boat being out of repair, we stopped here for the afternoon. This prairie was exceedingly beautiful. For an area of several miles in extent not the slightest undulation met the eye to break the level: only tall, luxuriant grass, fresh and green, with an abundance of the wild pea-vine with beautiful purple blossoms, and occasionally a fine grove of trees in which numbers of fallow-deer were quietly ruminating. Some of the passengers started out hunting, others amused themselves taking sketches and gathering the wild flowers which were scattered profusely over the green carpeted plain. About six miles distant arose the conical hills that form the river bluffs. These presented a tempting appearance to me, for I wished to examine their plants; and from the distinctness with which I could see them, I thought they could not be more than a mile or two distant. After traveling quite rapidly for an hour or two, hoping every moment to arrive at their base, I came to a deep, clear stream, about 30 yards in width, which was silently winding its way through the luxuriant grass that perfectly shrouded it from view. I then found, much to my chagrin, that I must either turn back disappointed in getting my rare plants, or swim the river, either of which alternatives was unpleasant. A herd of

red deer stood gazing at me from the opposite side with great curiosity, as if they were saying "come on," and, though I shouted at them, they seemed perfectly conscious of safety and showed no symptoms of fear. It was late in the evening when I returned to the boat. At almost every step the beautiful and fleet-footed fallow deer would spring up and hie far away out of sight. I saw many of their bones and horns, which showed that it must have been a great pasture ground for them. So pure and clear is the atmosphere in this region, that travelers unaccustomed to the country are often deceived as to distances."

The Missouri Valley proper extends from bluff to bluff, and it would be interesting to reflect for a moment, from our elevated position, in regard to the causes which have produced it. If we study the underlying rocks, we shall find that at Omaha the limestones of the coal measures are exposed near the bed of the river, and that they soon pass beneath the water level and are overlaid by the rusty sandstones of the lower Cretaceous period. If we follow them for hundreds of miles along the banks of the river on either side, we shall ascertain that they hold a horizontal position; that on one side the exposed portions of the strata correspond with those on the opposite side. Therefore, we come to the necessary conclusion that these rocks, to the summits of the highest hills on either side, once extended uninterruptedly across the area now occupied by the valley, and that the entire mass of rock material, however great it may have been, has been carved out of the solid beds for hundreds of feet in depth, and the sediments washed down and deposited on the bottoms below, or swept into the Gulf of Mexico. From Omaha to the mouth of the Big Sioux River, about 100 miles, the valley will average 10 miles in width; we have, therefore, in this short distance, at least 1,000 square miles of area and 600 to 1,000 feet in thickness of sediment, worn away and swept down toward the river and probably distributed over its bottom. We may make the same application to any other portion of the Missouri or the Mississippi Valley with greater or less striking results.

But as every portion of this valley is filled with impressive illustrations that produce thought, we can linger only for a short time at one locality. This is the Omaha reservation on which is located the celebrated Blackbird Hill, a point which, at some not far distant day, will be visited by the curious traveler. When I call to mind the many incidents that cluster about this spot, I find that, if fully described, they

would fill a volume. It is the best portion of Northern Nebraska, and was selected some years ago by the Omaha tribe of Indians, from the fact that it contains the burial place of one of their most noted chiefs, Blackbird, about whom many legends have been told.

At the present time, the Omahas occupy the southern part, while the Winnebagos, who formerly lived on the upper Mississippi, but were driven away at the time of the terrible Indian outbreak in Minnesota, reside on the northern side. Both of these tribes were originally nomadic, but at this time, they occupy a permanent settlement and are cultivating the soil with success. The following extract is taken from my journal of 1854:

"Near the close of the day we came in sight of a magnificent series of hills, which presented a conspicuous appearance in the distance, looking like gigantic pyramids covered with grass and trees. One of these forms a sort of landmark for travelers who visit the grave of Blackbird, a celebrated Omaha chief, whose story has been told many times by different individuals. We had made arrangements to visit the grave in the evening, but it was found more convenient to land the boat on the opposite side of the river. A very interesting legend is connected with the spot, which I will relate briefly, as given me by Mr. Culbertson, of the American Fur Company: The high bluff has received the name of Blackbird's Hill, from the fact that the noted chief of that name was buried on its summit. It is said that he made himself chief by the numerous murders he committed on individuals of his own tribe. If any man was so unfortunate as to offend him, or stand in the way of his promotion, he would predict his death on a certain day, when he would invite his victim to a feast and destroy him with arsenic which he procured, and the properties of which he learned from the French traders in the country. The fact that all died as he predicted made him a great medicine man, and much feared by the whole tribe, who were wholly unacquainted with the cause of his power. He died of the small-pox near this place, on his return from Washington, where he had made a visit in company with the agent. His dying request was to be buried on the top of the hill, with his face toward the sun, that he might see the Frenchmen as they ascend and descend in their boats. All his requests were literally complied with by his tribe. They buried him seated upon his favorite war-horse, with all the trophies of his long and successful life. Even at

the present time his grave is considered a sacred spot by the Omahas, who make frequent visits to the place and offer sacrifices of tobacco, beads, scarlet, ammunition, etc., to his spirit. Their present reservation includes this hill, and is one of the most delightful portions of Nebraska. No sign of the grave can now be seen from the river, and unless pointed out by some one acquainted with the country, it would be difficult for the stranger to determine the spot."

Along the banks of the Missouri River on this reservation is a lofty escarpment of yellow, rotten, coarse-grained sandstone, sometimes called Chalk Bluffs, from their whitish chalky appearance in the distance. They are from 100 to 150 feet in height, and about half way up, or at least 50 feet above the water, and as much from the top of this perpendicular wall, are carved out numerous Indian hieroglyphics, as pipes, canoes, various kinds of animals, rude representations of the Indians themselves, etc. The question at once arises who carved them here? The Indians, now living, cannot account for them, and call the rocks, "Medicine," a term which they apply to all things that are mysterious to them. The characters closely resemble those on their robes worn at the present day, and are doubtless emblematical of some important event in Indian history. These figures must have been carved here many centuries ago, when that portion of the escarpment was accessible from beneath, in a way all trace of which has been effaced by the water; similar ones are still to be seen in other localities, especially in the mountains. A small creek, which flows into the Missouri, a few miles below the "Running Water," has an Indian name which signifies, "where the dead have worked," from the fact, that upon the high chalky walls that form its banks are some of the same mysterious carvings. These soft sandstones, or chalky limestones, are well adapted for recording hieroglyphical history.

But these rocks bear upon them far plainer characters than those described above, and characters which carry the history of events infinitely farther back into the past than any ever carved upon stone by human hands. Near the Blackbird Mission, and in other localities above and below this place, has been found a remarkable series of fossil plants embedded in the sandstones and quartzites, which has thrown much light upon the ancient flora of this region. These sandstones all belong to the lower Cretaceous or Chalk period, and it is now well ascertained, that,

with the beginning of that era, began upon our continent the dawn of existing deciduous fruit and forest trees, as did also the present race of edible fishes, as the herring, perch, etc. We find impressions of leaves in rocks, remarkably well preserved, representing the genera Platanus, Populus, Fagus, Liriodendron, Sassafras, Magnolia, Ficus, and others. Some of these plants indicate a once warmer climate in this region than at present, though hardly tropical, or as Dr. Newberry has shown, not even sub-tropical, although on the Pacific Coast, species of the palm and cinnamon, indicative of a tropical climate, are found. It may be that when these rocks are more thoroughly studied, plants of a tropical or sub-tropical character may be found. I take pleasure in transcribing the following paragraph from Dr. Newberry's able report on these plants:

"It will be remembered that this vegetation grew upon a broad continental surface of which the central portion was considerably elevated. This would give us a physical condition not unlike that of the continent at the present day, and it would seem to be inevitable that the isothermal lines should be curved over the surface somewhat as they are at present. It may very well happen, therefore, that we shall find that the palms and cinnamons were restricted to the western margin of the Cretaceous continent. It will be seen by notes now given of the Tertiary flora of our continent, that, at a later date palms grew in the same region where these Cretaceous plants are found, but cinnamon and other tropical plants seemed to be entirely wanting in the Tertiary flora of the central parts of the continent, while on the west coast both palms and cinnamons lived during the Tertiary period as far north as the British line. We have, therefore, negative evidence from these facts—though it may be reversed at an early day by further observations—that the climate of the interior of our continent during the Tertiary age was somewhat warmer than during the Cretaceous period, and that during both, the same relative differences of climate prevailed between the central and western portions that exist at the present day."

Farther up the Missouri River, and resting on these sandstones and clays, is a thick bed of chalky limestone, containing vast quantities of a small species of oyster, and a large bivalve, *Inoceramus problematicus*, which is identical in species or closely allied with one found in many portions of Europe. Some remarkable forms of fishes, not unlike our shad or herring, also shark's teeth, have been found in abundance. A few

other shells have been discovered in various localities in this chalk, and all of them are strictly marine in character. Much of this limestone, though colored largely with the oxide of iron, is soft, and leaves a mark on a black board or cloth, like our common chalk of commerce. It is also composed largely of infusorial remains, as distinctly shown under the microscope. This formation, as well as that of the sandstone, is very widely distributed over the plain country in Nebraska, Dakota, and Kansas, and its influence on the agricultural prosperity of these regions is very great. The fertility of the soil is largely due to the calcareous matter of the one, mingled with silica derived from the other.

The cretaceous sandstones, containing the impressions of deciduous leaves, extend far southward through Nebraska and Kansas, and show very clearly, that this region was covered with quite luxuriant and extensive forests at this time. Then, again, during the same geological period, the sea rolled over all the area occupied by these forests. We see here the alternations of land and sea most clearly, and we shall show hereafter, that myriads of ages afterward the same region was clothed with still more luxuriant and extensive forests, the evidences of which have been preserved in the rocks higher up on the Missouri River. These are a few of the thoughts of the Creator, which have been hidden away for ages in these stony records, and which it is the glorious privilege of the geologist to reveal to the world.

But if I were to relate all the wonderful legends of the past which these records could unfold, it would require volumes, as well as years of time. I have only promised to cull here and there a flower sufficient to keep the geological connection of the story. The proofs of glacial action in the West are not common nor very remarkable in their character. Still they are shown to a certain extent, not only in the mountains, but also in the plains. Along the Platte River, below Omaha, and on the Missouri, near the city, the carboniferous limestones have had their upper surface so thoroughly smoothed by glacial action, that they can be quarried out and used for caps and sills, without any farther finish to them. And the process appears to have been carried on with wonderful uniformity, for the upper surface seems to be as level as if it had been wrought with a plumb-line. There are a few small grooves or scratches, and by means of a compass, I ascertained their direction to be about 27° east of north, or about N.E. and S.W. There seem also to be two sets of scratches crossing each other at different angles.

It would appear, from the evidence we have, that all the limestones underneath the yellow marl and pebble deposits around Omaha, and south to the Platte River, were smoothed or planed off by immense masses of ice passing over them, for wherever these superficial deposits have been stripped, the upper rocky layers are planed off with remarkable smoothness. In the mountains proper, the evidences of glacial action are not uncommon, especially on the sides of the deep valleys and gorges, but the causes were local and operated when the temperature of the climate was much lower than it is at present.

Although the cars of the Union Pacific Railroad are among the finest in the world, and although every convenience for traveling by night or by day can be furnished to us, perhaps even superior to any of the roads in the East, yet we shall find it far more instructive to plod our slow way across the great stretch of country, as the western trains of emigrants were obliged to do a few years ago.

It has been well said by Humboldt, that "to see is not always to observe," and we may now make our trans-continental trip with so much ease, comfort and speed as to be very little wiser for it, and gaining no profitable knowledge, only enabling us to boast that we have passed over this vast space.

Westward from Omaha we wend our way among the rounded grassy hills which rise in wave-like undulations as far as the eye can reach in every direction. The first glance at such a scene strikes the stranger with astonishment at its wonderful beauty, but it soon becomes so monotonous that any flat plain or rugged mountain is a relief. About 30 miles to the westward the road passes out of the hills into the valley of the Platte, and the journey westward is one gradual ascent to the mountains, walled on either side by more or less abrupt hills or bluffs. Here we may stop for a while to discuss some of the more important geological features, for the first 100 miles of our route. The surface deposits over this area possess no small degree of interest, both in an economical as well as scientific point of view, but I have already sufficiently explained their character. They seem, however, to occupy a very large area in this portion of Nebraska, concealing almost entirely the underlying or basis rocks. The geology, therefore, becomes somewhat obscure, and can be studied only at a few out-croppings, from point to point. The principal exposures are along the Platte, where the river has cut a wide and

deep channel through the surface of the country. The fact, however, that the strata are very nearly horizontal, that there are no upheavals, nor mountain elevations, to disturb the original positions of the beds, aids us much in our investigations. We believe, that the whole of Douglas County is underlaid by the limestones of the upper coal measures, with perhaps, a moderate thickness of the rusty sandstones of the lower Cretaceous or Dakota group, lying above them in the western portion of the county. At the mouth of the Platte, these coal-measure limestones are very conspicuous, and supply the greater portion of the building-stones of this region. The dip, if any, is quite gentle toward the northwest, and at the mouth of the Elk Horn River the Carboniferous limestones have passed beneath the water level of the Platte, not to be seen again until we arrive at the eastern margins of the Rocky Mountains. Overlying these are the ferruginous sandstones which contain the impressions of deciduous leaves. Near the mouth of Elk Horn are some of the abrupt bluffs of this sandstone, and the soft yielding nature of the rock has enabled the Indian to record on it his curious hieroglyphical history.

The question often arises in the minds of visitors to this region, how the law of compensation supplies the want of fuel in the absence of trees for that use. Many persons have taken the position that the Creator never made such a vast country, with a soil of such wonderful fertility, and rendered it so suitable for the abode of man, without storing in the earth beds of carbon for his needs. If this idea could be shown to be true in any case, we would ask why are the immense beds of coal stored away in the mountains of Pennsylvania and Virginia, while at the same time the surface is covered with dense forests of timber. We now know that this law does not apply to the natural world, and if it did, this Western country would be a remarkable exception. The State of Nebraska seems to be located on the western rim of the great coal basin of the West, and only thin seams of poor coal will probably ever be found. But in the vicinity of the Rocky Mountains, in Wyoming and Colorado, coal in immense quantities has been hidden away for ages, and the Union Pacific Railroad has now brought it near the door of every man's dwelling.

These Rocky Mountain coal beds will one day supply an abundance of fuel for more than 100,000 square miles along the Missouri River, of the most fertile agricultural land in the world. Every acre of land in

Eastern Nebraska is already in possession of the thriving farmer, and some of the most beautiful farms in the West can now be seen there. Although comparatively new, it looks like an old settled country. Farm-houses and small villages meet the eye in every direction, and the great interest which the more intelligent and enterprising citizens have taken in tree planting is covering the once naked hills with the most elegant artificial groves. The time is not far distant when Nebraska will be noted all over the world for the grandeur and beauty of its agricultural portions. Being composed entirely of plain country, with rocks of comparatively modern age, all holding a horizontal position or nearly so, without a single mountain range within its boundaries, Nebraska can never be remarkable in any way for its mineral resources. It is true, that it has its salt springs, which are annually becoming more important and valuable. These springs are located near Lincoln, the capital of the State, and the saline water flowing from them into Salt Creek has given character to quite an important tributary of the Platte, for 30 miles or more. This stream flows through a most beautiful rolling fertile region, covered with splendid farms, and has a deep channel, with steep muddy banks, a kind of forbidden object. Not a being can drink its waters, nor until near its entrance into the Platte do they, by accession of little streams and springs, become sufficiently freshened for the use of animals.

The valley of the Platte is a natural avenue through the country, from the foot of the mountains to the Missouri, and all the earthy materials which could possibly have ever existed over this vast area, from the summits of the highest hills on either side, and I know not how much more, have in the lapse of ages been swept down into the Missouri River, and then conveyed to the ocean to be distributed over its bottom, to form rocky layers for the study of future geologists. We may arrive approximately at the number of square miles of sediment which have been removed from this valley. It is at least 500 miles in length, and from bluff to bluff will average more than four miles in width for the entire distance. Taking this low estimate as a basis, we have 2,000 square miles of area, literally carved out and carried away. We cannot compute the thickness of the sediment at less than 1,000 feet, and it is altogether probable that it was much more. This vast change gives evidence of the tremendous forces of nature that have been continually at work all over this region. West of the mouth of the Elk Horn River, the

valley of the Platte expands widely. The hills on either side are quite low, rounded and clothed with a thick carpet of grass. But we shall look in vain for any large natural groves of forest trees, there being only a very narrow fringe of willows or cotton woods along the little streams. The Elk Horn rises far to the northwest, in the prairie near the Niobrara, and flows for a distance of nearly 200 miles through some of the most fertile and beautiful lands in Nebraska. Each of its more important branches, as Maple, Pebble, and Logan Creeks, has carved out for itself broad, finely rounded valleys, so that almost every acre may be brought under the highest state of cultivation. The great need here will be timber for fuel and other economical purposes, and also rock material for building. Still the resources of this region are so vast, that the enterprising settler will devise plans to remedy all these deficiencies. He will plant trees, and thus raise his own forests and improve his lands in accordance with his wants and necessities.

These valleys have always been the favorite places of abode for numerous tribes of Indians from time immemorial, and the sites of their old villages are still to be seen in many localities. The buffalo, deer, elk, antelope and other kinds of wild game swarmed here in the greatest numbers, and as they recede farther to the westward into the more arid and barren plains, beyond the reach of civilization, the wild nomadic Indian is obliged to follow. Geese, ducks and other kinds of wild fowl, with now and then a stray antelope or red deer may yet be seen, and the enterprising hunter may treat himself to a large amount of toil and a small amount of game. The underlying rocks as far west as Columbus and beyond, though very seldom visible, are well known to belong to the chalk period, and consist of yielding sands, clays and chalky limestones. These soft rocks, so readily crumbling under the atmospheric influences, have given a very gently undulating and rounded appearance to the entire surface. One may travel for days in this region and not find a stone large enough to toss at a bird, and very seldom a bush sufficient in size to furnish a cane. Yet this region is settling up with emigrants with great rapidity; railroads are now in progress of construction, or are in contemplation, and villages are springing up in numerous localities. The principal ones at the present time, are Fremont and Columbus. The latter, from its supposed central geographical position, has been regarded as the possible seat of the Capital of the United States in case of its removal to the West.

It may not be amiss to give a passing notice to one of the more interesting features of western life, which is now a portion of the history of the past. It was along the beautiful Platte Valley that so many thousands of emigrants and freight trains made their slow and laborious journey to the various parts of the remote West before the completion of the Pacific railroad. All these wonderful scenes can never be reproduced, and must soon be stored away with the dim records of the past; but all those who are now living, and have seen and formed a part, can never forget them. The construction of our railroads has so revolutionized the West, that at the present time we can see or realize very little of its former condition. Even the lonely graves by the road side have been obliterated so that hardly a trace of them is seen. Many years ago thousands of Mormons annually passed across these plains on their way to the promised land in Salt Lake Valley. In the spring of 1857 I saw a train of 90 hand carts drawn by women and children, passing up the valley, with more than 1,200 miles of uninhabited country before them. However old or feeble, they only desired to start on their way, fully assured that if they were faithful to the end they would receive the Crown. How many days of weary trial and suffering these poor people endured, and how many laid down the burden of life before they reached the end of their journey, we can never know.

The business of freighting was performed here on such a scale as to constitute one of the wonders of the West. During the entire season, either going westward in the spring or returning in the autumn, the white covered wagons could be seen stretching away for miles, and the evening camps would form a city with their multitudes and their noise and bustle. One writer has estimated that during the year 1865 there were engaged in this business 10,220 men, with 8,960 wagons, drawn by 14,620 mules and 59,440 cattle, carrying to its destination 54,000 tons of freight. He also estimates that, in teams and wagons alone, more than $7,000,000 were invested. Thousands of these immense freight wagons, capable of carrying 15,000 to 20,000 pounds weight each, abandoned and now gradually falling to decay, are scattered from the Missouri River to the Pacific Coast. From 1850 to 1860 the emigrant routes might be known by the dried up carcasses of mules and cattle that were distributed along the road. The dryness of the atmosphere is such that the bodies of the animals decay very slowly, seeming rather to dessicate, and their skele-

tons wrapped with their leathery skin endure for 10 or 12 years. Sometimes as many as one or two hundred of these animals would perish from some cause in one locality, and the plain would be strewn with their whitened bones. But all these scenes have passed away with nearly every trace of them.

Soon after leaving Columbus we cross Loup Fork or Wolf River, an important branch of the Platte which rises in the Sand Hills 150 to 200 miles to the northwest and drains a large area of country. In the summer of 1857 I had the opportunity of following it up from mouth to source in connection with an expedition under the command of Lieutenant now General G. K. Warren, U. S. A. Its lower portion passes through an extremely fertile region, but above the Pawnee reservation the Sand Hills begin to monopolize the country and render it unfit for settlement.

We now pass the eastern shore of one of the most interesting and most wonderful of those great lake basins which are found all over the West from the Missouri River to the Pacific Coast; there is no water in it at the present time, and its existence is only known to the student of geology. During the Tertiary period it occupied an area of at least 100,000, and very possibly 150,000 square miles. It will thus be seen that our greatest northern lakes of which we so proudly boast, are but ponds in comparison with some that once existed in this mountain region. The close observer will notice at once that he is passing into a district, the rock formations of which are quite different from any that he has seen before. He finds also that he is passing beyond the signs of great fertility, luxuriant vegetation, fine farms and fields of grain, to a comparatively arid, sterile region. Still, the broad bottoms of the Platte are covered with a fair growth of grass, but the chances for the successful cultivation of crops of any of the cereals are very small. The soil becomes too thin, sandy and arid for the growth of anything more than a scanty vegetation.

We might linger here for a moment and inquire into some of the causes that have produced this scantiness of vegetation and almost entire absence of trees over so large an area. There is quite a remarkable belt or zone of country along the eastern base of the Rocky Mountains, extending from the Arctic Sea far south to Mexico, upon which but a small amount of moisture ever falls. This has often been denominated the great American Desert. In years past this belt was supposed to

comprise the greater portion of the area lying between the Missouri River and the foot of the Mountains, but every year as we know more and more of the country, this belt becomes narrower and narrower, and as a continuous area it has already ceased to exist even in imagination. There are, however, large portions of the country that are comparatively worthless and arid, which may be called barren or sterile. It is now pretty well understood that the cause of the absence of timber in this great region is want of moisture. A very clear explanation of this subject, and one which seems in accordance with the facts, is given by Professor Dana, in *Silliman's Journal*, vol. 40, page 393. If we were to examine a rain chart we should find that where the forests are most luxuriant, as along the Atlantic Coast in the southern portion of the Mississippi Valley, the greatest amount of rain falls annually, say 50 to 65 inches, and as soon as we approach any of the interior basins of the Western Continent or any portion of this dry belt, we observe that the amount of moisture diminishes to 30, 20, 15, 10, and in some cases to as low as five inches annually. Again, along the Missouri River where the vegetation is quite extensive and the forest trees abundant, we have 20 to 30 inches of rain; but as soon as we pass to the westward 300 miles we have but 10 or 15 inches. On the Pacific Coast of Oregon and Washington, whose gigantic forests are celebrated all over the world, we find that from 55 to 65 inches of rain fall annually. We might multiply these illustrations, but the evidence seems to be conclusive.

There is another point that may be worthy of note here, and that is the prevailing impression among all the inhabitants of the West of a gradual change of climate by settlement and the cultivation of the soil. It is true, that over a width of 100 miles or more along the Missouri River the little groves of timber are extending their area, that springs of water are continually issuing from the ground where none were ever known before, and that the distribution of rain throughout the year is more equable. Such being the case, time may work important changes, and settlements may at some time cause a large portion of that belt which has hitherto been regarded as given up to sterility, to become of value for the abode of man.

The valleys of the Loup Fork and the Niobrara Rivers, although largely uninhabitable, are full of interest to the geologist. Located along these rivers is one of those grand cemeteries of extinct animals which

have excited the wonder of intelligent men all over the world. Farther to the northwest, on White Earth River, is another of these far-famed bone deposits. These two interesting localities bear such a relation to each other in the order of time and the relationship of the animals preserved in them, that they should be described in the same connection. I will, therefore, take the reader at once to the valley of White Earth River, near the southwestern base of the Black Hills, and there we shall behold one of the wildest regions on this continent. It has always gone by the name of "Bad Lands;" by the Canadian French as "*Mauvaises Terres;*" in the Dakota tongue, "*Ma-koó-si-tcha.*" These words signify a very difficult country to travel through, not only from the ruggedness of the surface, but also from the absence of any good water and the small supply of wood and game. In the summer the sun pours its rays on the bare white walls which are reflected upon the weary traveler with double intensity, not only oppressing him with the heat, but so dazzling his eyes that he is not unfrequently affected with temporary blindness. I have spent many days exploring this region when the thermometer was 112° in the shade and there was no water suitable for drinking purposes within 15 miles. But it is only to the geologist that this place can have any permanent attractions. He can wind his way through the wonderful cañons among some of the grandest ruins in the world. Indeed it resembles a gigantic city fallen to decay. Domes, towers, minarets and spires may be seen on every side, which assume a great variety of shapes when viewed in the distance. Not unfrequently the rising or the setting sun will light up these grand old ruins with a wild, strange beauty, reminding one of a city illuminated in the night when seen from some high point. The harder layers project from the sides of the valley or cañon with such regularity that they appear like seats one above the other of some vast amphitheatre. It is at the foot of these apparent architectural ruins that the curious fossil treasures are found. In the oldest beds we find the teeth and jaws of a Hyopotamus, a river horse much like the Hippopotamus which must have sported in his pride in the marshes that bordered this lake. So, too, the Titanotherum, a gigantic pachyderm, was associated with a species of hornless Rhinoceros. These huge rhinoceroid animals seem at first to have monopolized this entire region, and the plastic, sticky clay of the lowest bed of this basin in which the remains were found, seems to have formed a

suitable bottom of the lake in which these thick-skinned monsters could wallow at pleasure. As we pass higher up in the sediments, we find the remains of a great variety of land animals mingled with those that were aquatic in their nature. In a bed of flesh-colored marl which is visible for a great distance, like a broad band in the sides of these washed hills, thousands of turtles were imbedded and are preserved to the present time with surprising perfection ; the hard portions of them being as complete as when they were swimming about in these Tertiary waters hundreds of thousands of years ago. They vary in size from an inch or two in length across the back to three or four feet. But one species has ever been discovered in this basin, and so far as we know these reptiles made up in numbers what they lacked in variety. Associated with the remains of the turtles are those of a number of ruminants all belonging to extinct genera and possessing peculiar characters which ally them to the deer and the hog. Indeed, Dr. Leidy calls them ruminating hogs. Like the domestic species, they were provided with cutting teeth and canines, but the grinding teeth are constructed after the same pattern as those of all living ruminants. The feet of these animals were also provided with four toes as in the hog, and none of them possessed horns or antlers. They appear to have existed in immense numbers, and to have lived in great herds like the bison of the West. Remains of more than 700 individuals of one species have been already studied and described by Dr. Leidy. Their enemies were numerous wolves, hyænodons and sabre-tooth tigers.

If we pass for a moment southward into the valleys of the Niobrara and Loup Fork, we shall find a fauna closely allied, yet entirely distinct from the one on White River, and plainly intermediate between that of the latter and of the present period ; one appears to have lived during the Middle or Miocene Tertiary period, and the other at a later time in what is called the Pliocene. In the later fauna were the remains of a number of species of extinct camels, one of which was of the size of the Arabian camel, a second about two-thirds as large, also a smaller one. The only animals akin to the camels at the present time on the western hemisphere, are the lama and its allies in South America. Not less interesting are the remains of a great variety of forms of the horse family, one of which was about as large as the ordinary domestic animal, and the smallest not more than two or two and a half feet in height, with every intermediate grade in size. There was still another animal allied to the horse, about

the size of a Newfoundland dog, which was provided with three hoofs to each foot, though the lateral hoofs were rudimental. Although no horses were known to exist on this continent prior to its discovery by Europeans, yet Dr. Leidy has shown that before the age of man this was emphatically the country of horses. Dr. Leidy has reported twenty-seven species of the horse family which are known to have lived on this continent prior to the advent of man—about three times as many as are now found living throughout the world.

Among the carnivores were several foxes and wolves, one of which was larger than any now living; three species of hyænodon—animals whose teeth indicate that they were of remarkably rapacious habits; also five animals of the cat tribe were found, one about the size of a small panther and another as large as the largest wolf. Several of the skulls of the tiger-like animals exhibited the marks of terrible conflicts with the cotemporary hyænodons.

Among the rodents were a porcupine, small beaver, rabbit, mouse, etc.

The Pachyderms or thick-skinned animals were quite numerous and of great interest from the fact that none of them are living on this continent at the present time, and yet here we find the remains of several animals allied to the domestic hog, one about the size of this animal, another as large as an African hippopotamus, and a third not much larger than the domestic cat.

Five species of the rhinoceros roamed through these marshes ranging from a small hornless species, about the size of our black bear, to the largest, which was about the size of the existing unicorn of India. No animals of the kind now inhabit the western hemisphere.

Among the thick-skinned animals were the remains of a mastodon and a large elephant distinct from any others heretofore discovered in any part of the world. Dr. Leidy says that "it is remarkable that among the remains of mammals and turtles there are none of crocodiles. Where were these creatures when the shores of the ancient Dakotan and Nebraskan waters teemed with such an abundant provision of savory ruminating hogs?" During the Tertiary period, Nebraska and Dakota were the homes of a race of animals more closely allied to those inhabiting Asia and Africa now, and from their character we may suppose that during that period the climate was considerably warmer than it is at present. The inference is also drawn that our world which is usually

called the new, is in reality the old world, older than the eastern hemisphere.

Ever since the commencement of creation, constant changes of form have been going on in our earth. Oceans and mountains have disappeared and others have taken their place. Entire groups of animal and vegetable life have passed away and new forms have come into existence, through a series of years which no finite mind can number. To enable the mind to realize the physical condition of our planet during all these past ages is the highest end to be obtained by the study of geological facts. It has been well said by an eloquent historian, that he who calls the past back again into being, enjoys a bliss like that of creating.

We may attempt to form some idea of the physical geography of this region at the time when these animals wandered over the country and to speculate as to the manner in which their remains have been so beautifully preserved for our examination. We may suppose that here was a large fresh water lake during the middle Tertiary period; that it began near the southeastern side of the Black Hills, not large at first nor deep, but as a marsh or mud wallow for the gigantic Pachyderms that lived at the time; that as time passed on it became deeper and expanded its limits until it covered the vast area which its sediments indicate. We cannot attempt to point out in detail all the changes through which we may suppose, from the facts given us, this lake has passed, during the thousands of years that elapsed from its beginning to its extinction, time long enough for two distinct faunæ to have commenced their existence and passed away in succession, not a single species passing from one into the other. Even that small fraction of geological time seems infinite to a finite mind. We believe that the great range of mountains that now lies to the west of this basin was not as lofty as now; that doubtless the treeless plains were covered with forests or grassy meadows upon which the vast herds of gregarious ruminants cropped their food. Into this great lake on every side poured many little streams from broad valleys, fine ranging ground for the numerous varieties of creatures that existed at that time. Large numbers of fierce carnivorous beasts mingled with the multitudes of gregarious ruminants constantly devouring them as food. As many of the bones, either through death by violence or natural causes, were left in the valleys, they would

be swept down by the first high waters into the lake and enveloped in the sediments at the bottom. As the gregarious ruminants came down to the little streams or by the shores of the lake to quench their thirst, they would be pounced upon by the flesh-loving hyænodon, drepanodon or dinictis. It was probably near this place also that these animals would meet in fierce conflicts, the evidences of which remain to the present time in the cavities which the skulls reveal; one of these, of a huge cat, shows on either side the holes through the bony covering which had partially healed before the animal perished, and the cavities seem to correspond in form and position with the teeth of the largest hyænodon. The remains of those animals, which from their very nature could not have existed in great numbers, are not abundant in the fossil state, while those of the ruminants occur in the greatest abundance and were widely diffused in the sediments not only geographically, but vertically. The chances for the preservation of the remains of a species seem to depend upon the number of individuals that existed. The remains of ruminants already obtained, comprise at least nine-tenths of the entire collection, while of one species, portions of at least 700 individuals have been discovered. We might take examples from the animals that exist in this region at the present time that would illustrate the point. The wolves watch the deer, antelope and other feebler animals as they go down to the little streams for water, and all over the wide bottoms their skeletons are distributed in a more or less perfect condition. Whenever a bison becomes too feeble by disease or age to offer a successful resistance, the wolves soon dispatch him, and his bones are left bleaching on the ground. In most cases, these animals when pursued betake themselves to the water where they are not unfrequently drowned, or dispatched on a sandbar or island. Annually thousands of buffalos, in attempting to cross the Missouri River and some of its large tributaries on the ice as it is breaking up in the spring, are drowned. For many days their bodies are seen floating down the river by Fort Union or Fort Clark and lodging on some of the islands or sandbars, fill the air with the stench of their decay. In the spring of 1857 thousands of their bodies floated down the Kansas River past Fort Riley and were carried into the Missouri River. These animals are often mired in the marshes or the muddy shores of lakes or streams in great numbers. We know what vast numbers of the mastodon have been preserved in the Big Bone

Licks of Kentucky, and of the Irish elk in the bogs of Ireland. We might instance hundreds of examples to show how easily these animals, roaming and feeding along the numerous streams flowing into some great lake, could be transported in part or entire into the lake and sinking to the bottom, would be enveloped in the muddy sediments. There is another interesting feature in regard to these remarkable fossils, and that is the beauty and perfection of their preservation; the bones are so clean and white and the teeth so perfect that, when exposed upon the surface, they present the appearance of having bleached only for a season. They could not have been transported from a great distance, neither could the waters have been swift and turbulent, for the bones seldom show any signs of having been water worn, and the nice sharp points and angles are as perfect as in life. I have dwelt so long on the details of this great lake basin not only on account of the universal interest that invests it, and the wonderful treasures of the past which it has revealed to the world, but because its history is applicable in the main to the numbers of the other fresh water lake basins of the geological past which are distributed throughout the Rocky Mountain region. Before leaving this subject, there is another interesting topic of inquiry. Why such a beautiful series of vertebrate remains should be so perfectly preserved in this lake deposit, and yet the remains of other forms of animal and vegetable life be almost entirely absent. The sediments seem to be peculiarly adapted to the preservation of a full series of documents bearing upon the history of those times. And yet in the older beds where the mammalian remains are most abundant, only one small species of snail, a land shell, is found preserved. Where is the evidence of the swarms of fishes that must have filled the streams and lakes of that time? Of the vegetable life, if any existed, only now and then a fragment of silicified wood is found, and that, too, in the latest deposits. I am prepared to believe that the broad plains were, even at the time of the existence of these animals, as treeless as at present, yet I am quite unprepared to explain the almost entire absence of vegetable remains. We know that fresh water shells much like those existing in the little clear streams of the present time as well as some remains of fishes, are found in some limestones on the summits of hills near Pinos Spring on the northern rim of the lake.

Another interesting question occurs to me in this connection; how was it that a complete fauna, comprising more than 40 species of animals,

was introduced upon the earth, lived through its legitimate period, entirely perished or was swept out of existence and an entirely new fauna, comprising about the same number and variety, was again introduced in the same region. It, too, lived out its period of existence which must have been hundreds of thousands of years, and yet every one of this group of animals disappeared from the globe, leaving nothing behind to tell the tale but fragments of their bony skeletons, accidently enveloped in the sediment at the bottom of an estuary or lake.

It will be seen at a glance that this is a fruitful topic for speculation, and I leave it with the reader. Some of the species of animals found in the latest deposits seem to have lived very nearly up to our present period. The horns of a deer and the bones of a sand-hill crane have such a modern aspect that the thought arises, where was man when these animals were roaming over this region. Recent investigations show quite conclusively that man was an inhabitant of Europe cotemporaneously with many of the extinct animals of the Quarternary period, but it is doubtful whether we have ever found any evidence that he lived at a very remote period on this continent. Indeed, so far as we know at present, the West is singularly silent as to the existence of man in what are now understood as pre-historic times.

But let us move our camp farther south and toward the Platte Valley again, and on our way just glance at a desolate and almost barren but interesting region called the Sand Hills. They cover an area of about 20,000 square miles on both sides of the Niobrara River, and are composed of loose moving sand which is blown by the winds into round conical hills with considerable regularity. As far as the eye can reach the surface presents the appearance of a multitude of round tops, some of them scooped out by the whirling winds so as to resemble craters. These sand hills have been from time immemorial a favorite resort of the buffalo which feeds upon the scanty but very nutritious grasses in the little valleys and intervals among these hills. There is for the most part an abundant supply of water in the little lakes that are scattered throughout this region. Some of them are alkaline in the highest degree, and the fresh can be detected from the salt lakes by the presence or absence of vegetation in and around the borders. These hills are sometimes protected from the winds by a considerable growth of vegetation on their sides, especially the "Yuccas, or Spanish Needles," which seem to

grow even more luxuriantly in these almost soilless regions. No portion of the country is so barren or soilless as to be destitute of its peculiar vegetation, and even those portions that appear most sterile have some forms which flourish there best, and would perhaps perish if transported to a richer district. In the "Bad Lands" the soft succulent Cactus which draws most of its nourishment from the atmosphere, often covers the bald dome-like hills as if it would conceal their nakedness and sterility. These large moving bodies of sand are not uncommon in the West; in the North Park there is quite a large area completely covered with them, and as the surface reflects the light of the sun's rays, they appear in the distance like some extensive lake. Near the Mosca Pass in the San Luis Valley, is another group of sand hills which is quite conspicuous. The winds seem to delight in playing their antics in these places, throwing up the sand in the most beautiful wave-like furrows. Sometimes the strong winds that sweep over these vast plains will fill the air with a storm of sand so as to impede the traveler's progress for the time, and again they whirl it in circular columns far out of sight.

It will not be unprofitable to linger for awhile on the Pawnee reservation which is located in the Loup Fork Valley about 16 miles west of Columbus, and glean a few items of Indian history.

The Pawnees live in mud cabins or tents, and are called stationary Indians in contradistinction to the nomadic or wandering tribes. They cultivate the soil, raise good crops of corn, and in the intervals between planting and harvesting hunt the buffalo, retaining most of their savage customs and ideas. Time is counted by moons or months; January is called the cold moon; February, the snow moon; March, the warm moon; April, the moon of plants; and May, the moon of flowers, etc. They have dead moons and live moons. The following description of the structure of their dwellings was written by me some years ago while visiting the Arikara village on the Upper Missouri:

"The cabins or huts of the Arikaras and other stationary tribes are built by planting four posts in the ground in the form of a square, posts being forked at the top to receive transverse beams. To the beams, other timbers are attached, the lower extremities of which describe a circle, or nearly so, the interstices being filled with small twigs, the whole thickly overlaid with willows, rushes and grass, and plastered over with mud, laid on thick. A hole is left in the top for the smoke to pass out,

and another in the side for the door. This is the position of the building above ground, but within the circle an excavation is made two to four feet deep, and there persons can stand upright or walk about with ease in the interior, except at the portion of the circle where the beds of the inmates are made. The door opens a few steps distant from the main building, on the surface of the ground, from which by a gradual descent through a covered passage of about 10 feet, the interior of the hut is reached. The door is of wood, and the aperture large enough to admit a favorite horse to the family circle, which is often done. Around the house on the outside a small trench is dug to carry away the rain.

"These buildings are located within 15 or 20 feet of each other, without any regard to regularity; nothing like streets is found, and the houses are so much alike that a stranger is liable to lose his way in the village."

This tribe seems to differ from all others with which I am acquainted in having had an ancient custom of offering up human sacrifices. Even now, they have many superstitious rites and ceremonies at the time of planting corn, and also at different periods during the growth of the crops. The manner of offering the human sacrifice is well described in Major Long's account of an expedition to the Rocky Mountains in 1819-20, vol. I., and inasmuch as this work is not easily accessible to the general reader, I take the liberty of transcribing:

"The Pawnee Loups heretofore exhibited the singular anomaly, amongst the American nations, of a people addicted to the inhuman, superstitious rite of making propitiatory offerings of human victims to Venus, the *Great Star*. The origin of this sanguinary sacrifice is unknown; probably it existed previously to their intercourse with the white traders. This solemn ceremony was performed annually, and immediately preceded their horticultural operations, for the success of which it appears to have been instituted. A breach of this duty, the performance of which they believe to be required by the *Great Star*, it was supposed would be succeeded by the total failure of their crops of maize, beans and pumpkins, and the consequent total privation of their vegetable food.

"To obviate a national calamity so formidable, any person was at liberty to offer up a prisoner of either sex, that by his prowess in war he had become possessed of.

"The devoted individual was clothed in the gayest and most costly attire; profusely supplied with the choicest food, and constantly attended by the Magi, who anticipated all his wants, cautiously concealing from him the real object of their sedulous attentions, and endeavoring to preserve his mind in a state of cheerfulness with a view of promoting obesity, and thereby rendering the sacrifice more acceptable to their Ceres. When the victim was thus sufficiently fattened for their purpose, a suitable day was appointed for the performance of the rite, that the whole nation might attend.

"The victim was bound to a cross in presence of the assembled multitude, when a solemn dance was performed, and after some other ceremonies, the warrior, whose prisoner he had been, cleaved his head with the tomahawk, and his speedy death was insured by numerous archers, who penetrated his body with their arrows.

"A trader informed us that the squaws cut pieces of flesh from the deceased with which they greased their hoes, but this was denied by another who had been present at one of their sacrifices. However this may be, the ceremony was believed to have called down a blessing upon their labors of the field, and they proceeded to planting without delay."

Their system of counting differs from any other tribe known to me, except the Arikaras on the Upper Missouri, who speak the same language. Most of the tribes make use of the decimal system, or ten figures, but the Pawnee group counts by twenties or ten fingers and ten toes. Twenty is, therefore, one man; forty, two men, etc. Like all the Indian tribes of the West, the Pawnees are fast passing away, and soon we shall know nothing of them except what has been recorded in books.

The country bordering on the Platte River as well as on the Loup Fork contains the remains of many of the old villages, around which are found great quantities of fragments of pottery. In the summer of 1867 I discovered on the present reservation the remains of a village apparently of greater antiquity than the others, and the only one about which any stone implements have been found. On and around the site of all the cabins of this village I found an abundance of broken arrow heads, clipped flints, some of which must have been brought from a great distance, together with a variety of small stones which have been used as hammers and chisels. None of the Pawnee Indians living at

the present time know when this village was inhabited. A missionary informed me that more than 30 years ago, a chief, at least 70 years of age, told him that his tribe dwelt there before his birth, but that he had never known anything of the use of stone arrow-heads, though he said his people must have used them before the introduction of iron. I have asked the most intelligent Indians of more than 20 tribes in the valley of the Missouri how far back into the past their ancestors used stone arrow-points, and I have invariably received but one answer; they would point toward heaven and say: "The Great Spirit only knows, we do not." All along the valleys of streams flowing through Kansas and Nebraska are the remains of villages of the stationary tribes, as Omahas, Otoes and Pawnees, but the one just alluded to seemed to me of greater interest, because it was the first one in the Missouri Valley, through which I was able to connect the stone age with the present.

Since my attention was called to these chipped flints, about three years ago, I have found them in many places throughout the West, as at Pine Bluffs, in the Laramie Plains, Salt Lake Valley, Humboldt Valley, etc.; wherever there was a good camping place, the Indians would sit on the sunny sides of the hills and work out their flint arrow-heads and other implements of stone. But we cannot remain in this interesting region, and must push our way westward to "fresh fields and pastures new." We might spend weeks and months gleaning among the relics of Indian history, but this great pleasure must be deferred to some future time.

We shall now continue our way up the valley of the Platte with a good deal of rapidity. The country is monotonous, and yet now and then a fact of some interest might be gathered. We soon pass into what is called the Alkali district, where the ground is covered in places with a white efflorescence, which looks in the distance like snow. If the traveler were to ascend the highest hill that borders the valley and cast his eyes in every direction, he would see nothing but a gently rolling prairie without a tree or shrub as far as they could reach. No cozy farm-houses with all the signs of cultivated fields greet the eye; no groves of timber dot the landscape. For more than 200 miles along the valley of the Platte it would be difficult to find wood enough to kindle a fire. Fuel for the supply of Fort Sedgwick and the city of Julesburg, during the winter of 1865–6, when it was in its glory, was hauled from the

mountains near Denver, Colorado, a distance of more than 200 miles, at a cost from one to two hundred dollars per cord.

The surface of the country is sometimes weathered by atmospheric agencies into peculiar fantastic shapes. The rock formations are entirely composed of the whitish and yellowish-white clays, marls and sandstones of the more recent beds of the great Tertiary lake basin. The most striking examples are in the vicinity of Scott's Bluffs and Chimney Rock, which have been noted landmarks for years. The surface is here washed out into the form of domes, towers, churches and fortifications, and it is hardly possible to persuade oneself that the hand of art has not been busy here. Chimney Rock shoots up its tall white spire 100 to 150 feet. The strata are perfectly horizontal and, therefore, we may infer that the surface of the whole country was originally on a level with the summit at least, and that these landmarks are monuments left after erosion. These picturesque views south of White River are not extensive, although on both sides the North and South Forks of the Platte they occur in certain localities. A few fossil turtles and the bones of some huge animal, probably the Elephant or Mastodon, have been washed from the bluffs. At Antelope Station near Pine Bluffs, about 470 miles west of Omaha, a collection of curious bones was taken out of a well 68 feet below the surface, which were at once regarded by the people in the vicinity as human remains. These bones were distributed throughout the country and furnished many a sensational paragraph for the daily press. About two years ago, Professor Marsh, in visiting this country, made inquiry for them, and succeeded in obtaining a few fragments, from which he determined the existence of a small species of horse, which must have been originally about two or two and a half feet high.

From a mass of sediment 68 feet below the surface, 10 feet in diameter and 6 feet thick, Professor Marsh obtained a quantity of fragments of bones belonging to 17 different species of animals. In it were those of four varieties of the horse family, one of which was as large as the living domestic horse; one or two species of rhinoceros; an animal allied to a camel, and one resembling a hog; two carnivores, one about as large as a lynx, the other greater than any living carnivore, even the lion. Such a quantity of remains so varied in species and stowed away in so small a space has never been found before.

What a world of fossil treasures could be gathered if the whole

area south of the Platte and between the Platte and White Rivers were carefully examined by men of science! And even then, only those which are exposed to the eye of the geologist by atmospheric agencies would be found, while the great mass of rock material which underlies the entire surface is equally filled with them, and undoubtedly contains some forms that will never be recorded in the annals of science.

If we now take the cars we shall pass over a similar plain country until we reach Cheyenne, an important and rather remarkable city, near the foot of the mountains, 516 miles west of Omaha, 1,259 miles east from Sacramento and 110 miles north from Denver. This city is located in the open plain, near Crow Creek, a branch of the Platte, the hills ascending gently back to the mountains proper, which are plainly visible from the town. On the 4th day of July, 1867, there was but one house in this place; within three months there were at least 3,000 inhabitants with the bustle and confusion of a city of 10,000. It is now improving rapidly, and promises a successful future. Again, looking at the profile section of the railroad, we find that Omaha is 900 feet above the sea level. At Cheyenne, we have reached an elevation of 5,931 feet, yet the ascent has been so gradual over an apparently level plain, that we have not for a moment realized that we were ascending at the rate of nearly 10 feet to the mile. If the traveler has observed closely, he will have seen that nature had already performed most of the work of the road, and that there was not much more to be done but to lay the track, and that for the entire distance of more than 400 miles there were no rock beds to blast.

Before concluding this chapter, we will throw a momentary glance back upon the ground over which we have just passed. Nebraska may be divided into two portions: agricultural and pastoral. The eastern part contains some of the most beautiful, gently-rolling, fertile agricultural lands in America, the very garden spot of the country. But the western part is a treeless, almost waterless plain; yet, thick, low, sweet, nutritious grasses cover the entire surface, and for the raising of large herds of stock as horses, cattle and sheep, this country is admirably adapted. Not more than 15 to 20 inches of moisture fall here annually; the snows of winter are very light and soon pass away, the winds rapidly gathering them into the valleys or gorges, leaving vast areas entirely bare. The grasses, instead of decaying as in all countries with a humid climate,

slowly dry up, retaining all their nutritious qualities, and thus continue until April or May, so that all kinds of stock thrive throughout the winter in the open fields without other care, than that of the herdsman. The time cannot be remote when Western Nebraska, also Wyoming and Colorado, will be appreciated as a wool growing region, far surpassing any portion of the East.

In the autumn many of the streams of the plains dry up for the most part, although at long intervals water may be found. In ascending the valley, the water of Lodge Pole Creek will appear and disappear almost like magic. Here we find it a swift running stream several yards in width, and then for a considerable distance nothing is to be seen but its dry and dusty bed. Even the broad Platte has so far forgotten itself for several seasons as to cease to be a running stream: It is not uncommon for a river to be considerably larger toward its source than at its mouth. Many of the important streams that flow from the Black Hills into the Missouri are lost on their way through the plains. This is especially the case with rivers in the arid regions of New Mexico and Arizona.

CHAPTER III.

OVER THE FIRST RANGE.

OUR stop at Cheyenne must be short, although we could remain here several days with pleasure as well as profit. This town has passed through its mushroom growth, and is now moving steadily forward, and must ever continue to be the most important city between Omaha and Salt Lake Valley, along the immediate line of the Union Pacific Railroad. Many buildings of a permanent and costly character are already erected; schools and churches have been established, and all the outward signs of prosperity are visible. Comparatively little land in the vicinity is, as yet, under cultivation, but a fair beginning has been made.

The soil is fertile and must be quite productive where it can be irrigated. Better pasturage does not exist in the known world, and sooner or later this country must become celebrated not only for the quantity, but the quality of its stock. Along under the mountains and in the valleys of the little streams that flow therefrom, as the Lodge Pole, Chug Water, and others, very little snow falls all winter, and the grass remains very nutritious until late in the spring. All the roots and most of the cereals can be raised on the east side of the mountains. We have as yet scarcely caught a glimpse of the possibilities of this great territory, but I am convinced that its future will justify the most sanguine expectations of its able and enthusiastic Governor J. H. Campbell, and the officers and citizens who sustain him. It is one peculiarity of every good man who takes up his abode in the West, that he at once identifies himself with its material interests, and with him there is no limit to the

future prosperity of his new home, and the experience of the past has shown that in the main he is correct.

Two miles west of Cheyenne, we shall find Fort D. A. Russell, beautifully located on the north side of Crow Creek; but if we visit the gentlemanly officers of this post, we shall be induced by their kindness and generous hospitality to remain too long.

Before passing over the Laramie range, we will make a hasty visit southward to Colorado, the "Gem of the Mountains," or, as Mr. Bowles has so truly called it, "The Switzerland of America." Every step we take will be full of interest, and we shall be tempted to linger by the way continually. Cheyenne and Denver are now linked together by the Denver Pacific Railroad. But to profit by this visit, we should take the slower and more tiresome route by stage, close to the foot of the mountains. The road is an excellent one; on our right we can wander among the upland ridges and study, as in the pages of an open book, all the geological formations of this region from the most recent Tertiary to the granitic rocks that form the nucleus of the mountain ranges. These ridges or "Hogbacks," as they are called by the settlers, give a unique appearance to the scenery such as I have seen in no other portion of America. They ascend step-like to the base of the mountains; near Cache à la Poudre these ridges are very numerous, extending some five or six miles in width and finally dying out in the prairie like sea waves.

About 14 miles southeast of Cheyenne are some sandstones of the Coal period, which have been weathered by atmospheric agencies into singularly fantastic forms. They are called "The natural fort," and the place is rapidly becoming one of considerable resort. Near by we may enter a coal mine which has been opened and wrought to some extent. The bed is about five feet in thickness, but the coal is so light, and crumbles so readily on exposure to the atmosphere, that it has not met with much favor. Iron ore of the limonite variety is found here in great quantities strewed over the surface.

But that which will surprise and please the geologist in this region, is the thick bed of fossil oyster shells of a peculiar and extinct species which caps the summits of the hills above the coal. Fine specimens may be gathered here by the wagon load, and they are about the size, and must have existed in nearly as great quantities, as the small oysters now living on the shores of South Carolina.

On the South Boulder Creek near the foot of the mountains are some of the most remarkable coal mines in the West. I call the attention of the reader to these mines especially, because I believe that they will yet play a most important part in promoting the material prosperity of Colorado. Indeed, I believe that an area of 20 or 30 miles square between South Boulder and Golden City is destined to control the material interests of the State. Iron ore of a fine quality is found in connection with the coal in great quantities, so that not many years can elapse before iron works of great capacity will be erected under the shadow of the mountain range.

Denver is most beautifully located in the plains in the valley of the South Platte, about 13 miles east of the base of the mountains, and 5,300 feet above tide water. It has already passed the feverish, uncertain, speculative growth of its infancy, and is now moving steadily on to higher and better things. Costly blocks of buildings, enclosing clean, wide streets; the outskirts adorned with dwellings, surrounded with trees and gardens, now exist where the great American desert was supposed to hold its sway. All these magic improvements have been performed under the potent influence of the particles of glistening gold which have been hidden away in the earth for untold ages.

Coming from the luxurious cities of the East with the rapidity of the present facilities, the traveler will be surprised that in this region of snow-clad mountains he will miss very few of the comforts he has there enjoyed.

At all times, if the traveler turns his face to the West, he may behold from Denver one of the most beautiful landscapes in the world. But there are portions of the year, as well as different periods of the day, when these grand mountains are lighted up with a strange, almost spiritual beauty. The atmosphere is at times so pure and clear, that the snow-covered summits of the highest peaks seem almost within our grasp. It will not be many years till the beautiful, healthy valleys just at the foot of the mountains will each have its prosperous village and become famous summer resorts.

Winding our way up among these grand old mountains, we find good roads, the most attractive and ever-changing scenery, and fresh, pure, exhilirating air, that will make us glad and hopeful, and ready to see that which is pleasant alone. Thousands of flowers of varied hues will

greet our eyes on every side, and birds and quadrupeds such as we have not seen in our eastern homes will continually attract our attention. Among these mountains are beautiful valleys through which are winding, ever-flowing streams of pure water. Fine farms, with fields of waving grain, meadows covered with a thick growth of grass, gardens with all kinds of vegetables will meet the eye far more frequently than we have ever anticipated. The higher we ascend, the more wonderful and attractive scenery, tree, bird and flower become, until we stand upon the naked peaks of the main range amid the perpetual snows.

In no portion of the Rocky Mountains that I have ever visited are there any of those vast masses of snow and ice, or glaciers that give to Alpine scenery its wonderful interest. We find only little patches of snow in the deep gorges on the side of the lofty peaks, which send their sharp summits above the limits of vegetation.

Excellent roads and good coaches will take us to the Hot Springs of Idaho, where a delicious bath ever awaits us ; then, up the valley of Clear Creek, through the deep gorges, with the curiously banded gneissic rocks bent into the most fantastic forms, where will be seen at work on either side hundreds of people, diligently washing the loose gravel in the bed of the stream for the few particles of gold which are mingled with its sands. Soon we shall reach the little village of Georgetown, enclosed among the mountains with even now scarcely room to expand farther, a new mining town, filled with enterprises and hopes for the future. Here the interest in this remarkable scenery, which certainly cannot be surpassed for beauty and rugged grandeur in the known world, with its swift flowing streams of the purest mountain water, is lost or forgotten in the thought that these mountains are crowded with lodes of the finest silver in the world. And the surprise will be the greater, when we consider the obstacles that have been overcome by human energy, in exploring these inaccessible mountain sides which rise nearly vertically 2,000 or 3,000 feet. And yet no difficulty has been so formidable that it has not been met and overcome by the courageous, hopeful miners in search of the precious mineral. So, too, at Central City, we shall be tempted to linger long by the way-side, and forget that our route is westward, far beyond the main range, to the sources of the Pacific waters.

I am of the opinion that we have not formed a full conception of the great future that is awaiting these gold and silver mines. I believe them

to be practically inexhaustible, and when new processes are discovered for more successfully extracting from the lean ores the precious metals which are now lost, there will be no limit to the wealth that will flow from this region to the world.

From this point we might make a short visit to the Middle Park, by way of Berthoud's Pass. It will not be long before a good wagon road will be built across this range, and then the most timid seeker after health and pleasure can enjoy the beauty of this trip. I have taken my reader thus far out of the regular route, because I believe that some of these localities surpass all others, even in the West for a summer pleasure excursion.

There are several roads which lead to the Middle Park, but the one which passes up a branch of Clear Creek, by way of Berthoud's Pass, will probably be the most traveled in future. Empire City is a small mining town, mostly deserted at this time, but located in a beautiful mountain valley, 8,583 feet above the level of the sea. As we ascend the steep sides of the mountain, we find that the arborescent vegetation dwindles more and more, until near the summit the shrubs trail on the ground. The summit of Berthoud's Pass is 11,394 feet above the sea, and yet it is covered with a beautiful carpet of grass and flowers, even among the crevices where the snow has remained for ages. Many varieties of the Alpine type are seen, such as the Claytonias, Phloxes, Gentianas, Violets, Dodecatheum, Anemones, and a great variety of others, none of them scarcely more than an inch or two in height, but covering the ground, giving everything about us the appearance of spring. Indeed summer at this elevation does not properly exist at all. There are really only two seasons, spring and winter. Upon this Pass we stand on the dividing line which separates the waters of the Pacific from those of the Atlantic. As we pass across the summit we observe a piece of wet boggy ground, and descend the valley of a little stream which at first is scarcely visible, and before evening we camp by the side of it where it has grown to be a river 30 yards in width. The Middle Park, from any of the ranges of mountains that wall it in, presents the most striking and wonderful views. It would be difficult to discriminate between them and decide which surpasses the rest. The habit of using superlatives will grow upon us so that they will form the greater part of our forms of speech, and common language will prove altogether too tame for our purposes. We

might visit the Hot Sulphur Springs which must soon become one of the most favorite localities in Colorado. These springs are situated on the right bank of the Grand River, just at the head of a magnificent granite cañon, through which the waters of this river flow. Just back of the springs is a fine lofty mountain, rising 800 to 1,000 feet above them, which bears the name of Mount Bross, in honor of a most excellent gentleman, the Hon. William Bross, of Chicago, Illinois, who visited this neighborhood about two years ago. It will undoubtedly always be recognized by this name, and for the thousands of visitors to this delightful spot, it will form one of nature's grand observatories. From its summit one can easily see in a clear day a distance of 50 to 100 miles in every direction.

I have wandered through the region of the Rocky Mountains, from the north line of the country to New Mexico, and yet I have never seen such an abundance of fine trout in any of the mountain streams, as in the Grand River and its branches, even surpassing the Rio Grande of the San Luis Valley in numbers, if not in size and quality. I think it is safe to say that in a small stream, about 15 miles north of the Hot Springs, called Troublesome Creek, one could catch with a hook 200 to 300 pounds of fine trout in a single day.

The North Park is separated from the Middle Park by a lofty range of mountains, and it is best reached from the Laramie Plains. But to visit the Middle, South and San Luis Parks we should travel by way of Denver. But take what direction we may, follow what one of the numerous roads we will, visit as many of the localities of interest as we may, we shall always return unsatisfied. We cannot see all, the area is too large, and it would seem as if the last situation examined again presented to us new features of interest. We cannot bid farewell to Colorado without regret, and without an inward or perhaps outward promise to visit it again at the earliest possible moment. From the Cheyenne to Granite Cañon, near the summit of the first range, the grade of the ascent is greater than between any other points along the Union Pacific Railroad. The distance is about 19 miles, and the difference of elevation between the two places is 1,867 feet, or a grade of more than 90 feet per mile. The recent Tertiary beds lie close up to the flanks of the mountains, over a belt of several miles, affording a comparatively easy transition from the newer formations to the granite nucleus. For

hundreds of miles either north or south of this line, it would be difficult or perhaps impossible to build a railroad across the mountains, but here nature seems to have provided an easy inclined plain to the very margin of the mountain summit. The ridges are very nearly concealed, while on either side they can be seen as formidable as anywhere along the eastern base.

Close up to the sides of the mountains this more recent formation is composed of water-worn boulders and pebbles, varying much in size, but as we recede eastward toward the plain they disappear for the most part. The same is the case with the drift, which shows clearly that the causes which led to the deposition of these beds operated in the vicinity, and the materials are derived from the mountains near by.

On either side of this inclined plain, north or south, we can see the upturned edges of the different sedimentary rocks in this region. Between Granite Cañon and Cache à la Poudre, about 40 miles along the foot of the mountains, not only is the scenery rugged and grand to the eye, but the complications of geological structure are very interesting. There seems here to have been a jog in the minor ranges which compose the aggregate range, and several of these smaller ones disappear in the plains. The belt of upheaved ridges is here 10 to 15 miles wide, revealing all the sedimentary rocks, from the Carboniferous limestones to the most recent Tertiary beds. The peculiar brick-red color of the sandstones, which are supposed to be of the Triassic age, gives a singular appearance to the scenery. We have here the Carboniferous limestones resting upon the granites, then a series of brick red sandstones inclining at different angles with beautiful grassy valleys between the ridges, and little streams cutting through nearly at right angles, then a thin group of sand and marls which may be Jurassic, then the whole series of Cretaceous beds with their characteristic remains, then the Lignite Tertiary beds with coal, all conforming to each other, and all inclining from the mountains at different angles. All the beds just alluded to, perfectly conform to each other, but the light colored rocks which most attract the eye of the traveler at Cheyenne do not conform, and were of course deposited subsequent to the uplifting of the mountain ranges. We can see, therefore, that the eastern flanks of these mountains formed a shore line for a great fresh water lake.

If we make our investigations still north of this line, we shall find for 200 miles or more, that these recent beds jut up against the older sedi-

mentary beds, and in many places rest upon the granites. Sometimes the whitish rocks have been removed by erosion, so as to expose the older ones, but near Laramie Peak they entirely conceal all but the granites. In many places these recent beds are found high up on the flanks of the mountains in a nearly horizontal position, as if many of the outer peaks were mere islands in this great lake, much like those in Salt Lake at the present time. I have said enough here to show the reader that from Cheyenne to the summit of the first range, he is passing over a thick shore deposit of an ancient lake which once covered a vast area, very much larger than that of any of our fresh water lakes of the present day. The cuts along the road do not show all the formations in this vicinity. The traveler must stop a day and wander away from the line of the road if he would make his geological observations complete.

The recent beds rest directly on a stratum of white limestone of carboniferous age. This limestone is very useful to the citizens of the territory inasmuch as it can be burned into lime of the finest quality. The walls of houses plastered with it are as white as snow, and it is a great favorite with masons. The supply is inexhaustible, although it is not exposed anywhere along the mountains in any very great thickness.

These limestones are regarded as of the same age as those we saw at Omaha and along the Platte, and if so, they must have been concealed over this long distance, at least 500 miles, and had it not been for the upheaval of these mountains, would never have been exposed to the eye of man.

The science of geology continually shows how entirely dependent upon causes which were in operation many ages ago, are the most practical results of man. Like the ripe fruits which so many pluck from the tree, and enjoy without a farther thought, so these important benefits are accepted by mankind, and how few are thoughtful enough to inquire from whence they come.

The stupendous erosive agencies which have in most cases scooped out deep valleys just at the foot of the mountains, have left this portion remaining of the inclined plain which I have described as extending from Cheyenne to Granite Cañon, and underlying the western shore of a great lake, and thereby rendered it possible for the Pacific Railroad to pass over the range, saving to its enterprising builders millions of dollars.

We shall endeavor to show along the line of the route that this

great road was really constructed in far past geological times, and it was left for man to discover and avail himself of the advantages of the secret workings of nature. The summit of this range presents some scenery which is quite unique and remarkable, differing in many of its features, from that at any other point along the road. It would well repay the tourist, and especially the artist, to spend several days here; the air is delightfully exhilarating and cool, the water pure as crystal, and all parts easily accessible. The little streams are full of fish, especially trout, and game is moderately abundant; black-tailed deer, red deer, and antelope are yet found, though becoming less abundant every year, and with two or three kinds of grouse and woodcock will reward the sportsman.

The rocks which compose the nucleus of this range are granites, or inasmuch as they present a great variety of texture I have chosen to call them granitoid. Sometimes the rocks are made of large crystals of feldspar and quartz, with very little or no mica, forming a coarse feldspathic granite, sometimes the constituents will be quite uniform and a fine grained compact and most durable rock will be the result. Again, some constituent of iron will prevail, and disintegration is rapidly effected by atmospheric agencies. The surface of this range is literally paved with small fragments of rock, and the natural roads that are made in the mountains are macadamized with feldspar. Building materials are abundant, and as extensive as the mountains themselves. Picture II. illustrates a massive hill of Syenite which looks in the distance like the ruins of some gigantic old castles. This is a close compact massive granite, rather fine-grained and susceptible of polish, much like the Scottish Syenite.

The directors of the Union Pacific Railroad contemplate transporting this beautiful rock to Omaha, to construct with it the piers of the bridge across the Missouri River. I believe it will prove as durable, and far more elegant, on account of its brighter color than Quincy granite.

The cuts along the road furnish excellent opportunities for rock study. They are as it were, portions carved out of the crust, and we can thus obtain more accurate notions of its geology than in any other way. The surface has often been so changed by erosion that the loose material that has fallen down the sides of natural gorges in almost all cases obscures to a greater or less extent the true character of the rocks,

and I have found these excavations of the greatest importance in my examinations, correcting many an erroneous view.

Picture III. is an excellent illustration of one of these cuts through the different kinds of granite. On the right side of the track the rock has been disintegrated for a considerable distance down by moisture, and the feldspathic crystals project from its sides with great distinctness. A heavy vein of quartzite, is also distinctly shown. In the distance we catch a faint glimpse of one of these massive granite piles, which are so well shown in picture II. The character of the surface of this range of mountains which is about 20 to 30 miles in width is also well shown. Large areas are comparatively level, and covered with a thick growth of grass, with here and there a thin grove of pines. These trees are hardly ever more than from 50 to 60 feet high, and seldom more than two feet in diameter at the base. Farther up in the higher ranges, the white spruce and several other species of coniferous trees are found.

Picture II. forms an excellent rock study, and it is a fine illustration of the style of weathering of the feldspathic granites. These massive piles, like the ruins of old castles are scattered all over the summit of the Laramie range, and the difference in texture of the rocks is such, as to give a most pleasing variety, hardly any of these piles being alike. These rocks were once angular masses, probably nearly cubical blocks, and they have been rounded to their present form in the process of disintegration by exfoliation. Nature seems to abhor all sharp corners or angles, and with her, the curve is the line of beauty. Time wears off all the sharp points in thin spherical layers year after year. Skull rock is another example of the tendency to wear into singular shapes. This rock which has given name to one of these striking rock masses, has been peeled off, coat by coat, by the fingers of time until it presents a very close resemblance to a human cranium. If we were to descend the beautiful valley of Dale Creek, we should find the scenery even more romantic, and the granites worn into more fantastic forms. There is one portion of this valley which has long been celebrated for the beauty of its scenery, and known to the country as Virginia Dale. The swiftly flowing stream winds its way through the overhanging rocks which sometimes run up a thousand feet or more with nearly vertical sides, and among these massive granite piles are grassy oval park-like areas, which must become at some future period favorite places of resort. The character of the

scenery, and the style of weathering of the rocks are well shown in photograph III.

Sherman, on the summit, is well-known as the highest point over which the railroad passes between Omaha and Salt Lake Valley.

We might linger for a time here and admire the beautiful and unique scenery which is unfolded to us on every side. We shall not meet with its like again in any other part of the West. Long's Peak with its double spires rises above the limits of vegetation into the regions of perpetual snow, more than 14,000 feet above the level of the sea. All around are less lofty cones, many of them so covered with pines that they look black and sombre in the distance. Far to the southwest are the snowy ranges that surround the North Park, and in the intermediate space are groups of lower peaks, or cones rising like steps to the higher ranges. There is an interesting thought just here as to the real origin of these granitic ruin-like piles that give the peculiar distinction to the plateau surface of the Laramie Mountains. I believe it is entirely due to erosive forces which have operated here on a gigantic scale, and these cones and natural temples are the monuments that are left to tell the tale. I am convinced that the surface was at one time, at least, on a level with the highest of them.

How much more has been removed it is now impossible to tell, but I am convinced that comparatively few geologists have fairly estimated the immensity of the time required, and the vastness of the amount of material removed from the surface by erosion.

Three miles west of Sherman we cross the head of Dale Creek, a small stream which flows through a wide gorge-like valley in the granitic rocks. Spanning the valley is a bridge 650 feet in length and 126 feet above the little stream. This bridge, which is well worthy of examination, forms one of the most beautiful structures of the kind along this road, and always attracts the attention of the traveler, who looks down from it upon a beautiful grassy valley through which winds a small stream, the whole walled in with massive granite, like that before described. After crossing the Dale Creek bridge we descend rapidly to the plains; on the west side of the mountains we pass across the inclined edges of formations which appear to be counterparts of those already alluded to on the east side. We find the sandstones resting upon the granite, and inclining at a greater or less angle westward, we also find the whitish and

yellowish white limestones of the Carboniferous period, also the red sandstones which have usually been regarded as Triassic, though I suspect that the upper portion at least is Jurassic, then come loose red sands, extending a considerable distance into the plains. If we continue on toward the Big and Little Laramie Rivers, we shall find the Cretaceous beds in full development in nearly horizontal position, and about 30 miles still farther west the coal beds of the Tertiary period are seen.

But before we commence our general remarks in regard to this mountain range, let us linger for a time among the singular and grotesque forms which nature has hewn out of the sandstones on this western slope. Here we may study some excellent illustrations of the wearing away of sandstones through atmospheric agencies. We wish as far as possible to present to the reader type-examples of the influence which the atmosphere in its varied phases has in shaping the features of the landscape.

We have illustrated some of the granitoid rocks of the mountain's nucleus which have been metamorphosed by heat. Photograph V. is exceedingly instructive in many points of view. The rock itself is a moderately fine grained sandstone, and varies in color from a yellowish white to a light brick-red, and is probably of Jurassic age. No organic remains have ever been found in the sandstones, although I have traced them along the mountain sides from our north line to Santa Fe. The reason why I call them Jurassic is, that a bed of limestone which inclines from the flank of the mountain higher up, seems to hold a lower geological position, and contains the remains of Crinoids which Professor Agassiz refers to the genus *Apiocrinitas*, which is Jurassic. To this place has been given the name of Dial rock on account of the peculiar dial shaped form into which one of the columns has been worn. We see at a glance that these rocks are stratified, that they hold a nearly horizontal position, that they stand out in the plains nearly isolated, although in the immediate vicinity are many other equally fantastic forms, covering quite an extensive area. Where are the intermediate portions of the rock out of which these singular monuments have been carved by the chisel of time? These level plains, covered now with grass and wild sage, were once on a level with the summits of these sandstones at least, while the vast mass of sandstone, which filled up the general level has been swept away, who knows where? Who can estimate the forces that have wrought

this mighty work, or the immensity of the time that it required. How many myriads of ages have the winds and storms beaten against the sides of these rocks, gnawing out the cavities and giving the fantastic shapes they now possess? Every year smaller portions crumble off, and are mingled with the soil below, and in time all these remnants of the past will be removed. It will be noticed that the larger mass is worn into a form that can easily be imagined a human face, and an American might fancy he saw in it some resemblance to that of the Father of his country.

It is not an uncommon thing for the rocks of all textures, in this country, to weather into the forms which call to mind human beings and animals.

These sandstones also afford a fine illustration of what is called irregular layers of deposition, and the materials are supposed to have been brought here and deposited in turbulent waters. If we were to study the actions of currents of water along our streams, or of the waves of the sea shore, we should continually find examples of the deposition of sandy material over an inclined plain; sometimes on one side of a ridge or elevation, and sometimes on the other. Now, if this sand were moulded into rock, these layers of deposition would show distinctly this same irregularity. Not far distant from this point is another group of these weathered sandstones which show still more clearly these irregular layers. The softer portions have been worn away, causing each thin layer to stand out of the sides of the rocks with great distinctness. Sometimes the layers incline in one direction, sometimes in another. These sandstones vary in height, from 50 to 150 feet. On their summits, the eagles are fond of building their nests where they will be inaccessible to their human enemies. Before closing our description of photograph V., I ought to allude to the wild sage bush which so peculiarly characterizes these almost treeless plains. We are here more than 7,500 feet above tide water; at this elevation we find a species of sage which takes the place of the one on the plains east of the mountains. It is called Artemesia Trifida on account of its small three-toothed leaf. It grows about the same size and very much resembles the other species. This sage, as well as two or three kinds of shrubs peculiar to the high places, are well shown in the photograph.

We have now described briefly the different sedimentary formations as they incline either side of this mountain range. It may be well to

remind the reader that this range is an excellent illustration of the plan of development of these mountains as presented in chapter I. We find a series of formations inclining from the eastern slope of the mountains, we pass over the range and we again find the corresponding portions dipping in an opposite direction over the western slope. We at once come to the conclusion that these formations at some former period extended uninterruptedly across the area now occupied by the granitic rocks, and that the intermediate portions have been removed by erosion. Then the query arises, at what time were these events brought about? It seems to me it must have occurred as the surface was slowly emerging from the waters of the ocean. As the bottom of the ancient sea along the line of this mountain range slowly arose, the waters became shallow, and they would be more easily distributed by the winds and the erosive forces be proportionately increased, and if the rocks arose above the surface, the waves would dash against their sides and prove still more effective. The sediments would be wafted away and deposited in some other part of the ocean to enter into the composition of more recent rocks.

The Laramie range, extending from a point near Long's Peak northward to the Red Buttes on the North Platte with the Black Hills of Dakota, form the most simple and complete examples of true anticlinals on a gigantic scale that I have ever met with in my explorations. These ranges are less complicated with basaltic outbursts than any others. Some of the Peaks, like Laramie Peak, are quite lofty, but as a general rule they are low mountains, and for the most part composed of a nucleus of massive red feldspathic granites enclosed on either side with true gneissic strata. All these mountain ranges require a few more detailed examinations than I have ever been able to give them, but the statements that I have here made will, I think, prove to be mainly correct.

CHAPTER IV.

THE LARAMIE PLAINS.

IN our first chapter we descended the western slope of the first mountain range to a broad, open expanse of mountain prairie known as the Laramie Plains. This great area might be called a park; it is enclosed on three sides by extensive mountain ranges, but on the west its limits are not well defined, inasmuch as no mountain ranges of any importance intervene until we come to the Wasatch range, in Utah. It is usually understood to extend westward almost to the Medicine Bow River, and thus comprises an area about 50 miles from east to west, and 100 from north to south, the Laramie range or Black Hills forming the eastern boundary. As we ride on the cars through the plains, these mountains, with their comparatively uniform and gently sloping side, seem for many miles to bend around so as to enclose us within their walls. On the south side are the Medicine Bow Mountains, which are far more formidable and lofty than the others; indeed, the ranges this side are quite irregular and fragmentary, and are known by different names, as Sheephead Mountains, Elk Mountains, etc. Many of these lofty peaks and ranges have not yet been explored geologically or geographically, and these magnificent fields are ripe and waiting for the harvest of science. The far West is vast, but the laborers are few.

Before proceeding, we might for a moment trace to their sources in the mountains some of the beautiful rivers that wind their way through the plains. We shall find to our surprise that, although we have crossed a range of mountains the highest along the line of the road, we are still in the great valley of the Platte in which we started on our journey.

The main branch of the North Platte rises in the range of mountain which forms the north side of the Middle Park, very near Long's Peak. It takes a course a little west of north, flows through the middle of the North Park, cutting its way through immense cañons between the North Park and the Laramie plains. It then continues nearly a north course through Tertiary as well as Cretaceous rocks to its junction with the Sweet Water, where it bends around to the east so that near the Red Buttes its course is nearly southeast until it reaches the main Platte near longitude 101°.

The Sweet Water, which is the principal branch of the North Platte, rises in the southern end of the Wind River Mountains, and flows nearly east and unites with the North Platte near Independence. These streams flow through nearly every variety of geological formations which occurs in the West. From the junction of the Sweet Water to the Red Buttes, it flows through granite, carboniferous limestone, red beds, Jurassic marls, and White River Tertiary beds, and from the Red Buttes, through Lignite Tertiary to a point about 100 miles northwest of Fort Laramie. There, the White River Tertiary beds overlap the Lignite Tertiary, and then continue to the forks of the Platte.

The Medicine Bow and the two Laramies are important branches of the North Platte, and take their rise in the lofty snow-capped mountains on the north side of the Laramie plains. The region north of the North Platte is mostly a vast sage plain and but few small branches flow in from that direction, but a multitude of small streams cut deep channels through the sides of the Laramie range and flow into the North Platte.

From Red Buttes to Fort Laramie, a distance of 150 miles, many beautiful little streams rise in the Laramie and pour a good volume of water into the Platte. These creeks occur every few miles, and in their passage from the mountain they have not only worn a deep channel in the steep side of the mountain, sometimes 1,000 feet or more in depth, but they have also scooped out a wide, deep valley, which affords the best of pasture ground for stock in summer and warm, sheltered places in winter.

The main branch of the South Platte rises in the range of mountains which bounds the west side of the South Park, and flows about northeast to Cache à la Poudre, and there bends round slightly toward the east and joins the main Platte. The little branches that flow from the mountain

sides are very numerous, and each one cuts a tremendous channel through the sides of the mountain, affording most excellent sections of the strata for the geologist. Nearly all the branches that rise in the plains have very wide valleys, but are mostly dry, especially in the latter part of summer and autumn. Although the Platte River is never navigable at any season of the year, yet the area drained by it is immense, being nearly 300,000 square miles; and yet the North Platte is one of the minor branches of the Missouri River.

The South Platte flows through the different formations along the flanks of the mountain; and in its course through the plains cuts the Lignite Tertiary for 50 miles or more, when the White River Tertiary overlaps the plains to the junction.

These brief remarks are intended principally to show by the geography the gigantic scale upon which everything in this Western country is planned; that even the district drained by the Platte and its branches is larger than all New England, New York and Pennsylvania.

Myriads of little streams rise in springs on the summits of all the mountain ranges, and flowing down the sides, gash out deep gorges which afford most splendid sections of the rocks for the study of the geologist. And as for beautiful scenery, there is no limit to it. If we were to trace these streams to their source in the mountains, through gorges and chasms, into beautiful oval grassy valleys, up the precipitous flanks where they expand in numerous little branches, rushing and tumbling over the rocks, we should involuntarily pronounce each one at the time more grand, more beautiful and more instructive than any we had ever seen before. It is impossible to describe to the reader the pleasure one enjoys in wandering among these mountain valleys, climbing the almost vertical cliffs and studying the almost unlimited variety of forms which the masses of rock present. Then, too, the vegetation, seen in summer, has the green, fresh appearance, that is so inviting and grateful; and the grass, flowers, trees, all wear that healthy look which is only to be met in the mountains. Although the Laramie plains are at too high an elevation ever to become noted for their agricultural resources, yet the few attempts to raise certain crops have met with moderate success.

In the summer of 1868 some farmers in the valley of Rock Creek, along the line of the old stage road, succeeded in raising some very good vegetables, as potatoes, turnips, cabbage, etc., and they would have

remained there contented, had they not been driven away by the Indians. But it is doubtful if these plains will ever become a favorite abode for farmers, though for the raising of stock, I believe, they are unsurpassed. Horses, cattle and sheep have already been raised here of the finest kind, and in the beautiful, sheltered valleys, they find the most secure retreats from the severity of the winter's cold. Thousands of tons of excellent hay can be cut every year along the bottoms of any of these streams.

Photograph VI. is a type view of the plains proper as seen in the valley of the Little Laramie, near Sheephead Mountain. We see here the meanderings of the little stream; the fringes of cotton woods, willows, and a few "shrubs," in the immediate bottom, the level lawn-like terraces covered with a thick carpet of grass, and gradually ascending to the hills on either side. The entire surface has been so perfectly softened down by time that the beauty of the scene is perfect. It is true, the plains are not at all times as uniformly smooth, as the picture would indicate. Not unfrequently the surface is rugged in places; masses of sandstone, or limestone with steep sides rising in the midst of the plains,—monuments left after the action of the waters that have smoothed down these beautiful landscapes. It would seem that they are left to aid us in reconstructing the geography of past geological times.

Near the middle of these plains, on Cooper's Creek, are some quite remarkable exhibitions of the chalk cliffs of the middle Cretaceous period, in which are oyster-shells, fish-scales, and the bones of a huge Saurian reptile. A little farther to the west is a long line of yellow sandstone bluffs 200 to 300 feet high, being beds of transition or passage between the Cretaceous and Tertiary periods; and still farther west are more rugged hills in which are found beds of coal. We see, too, everywhere indications of the actions of water on the surface of the plains. In many places rounded boulders of all sizes from the minute pebble to a mass two or three feet in diameter are found scattered profusely over the ground. Sometimes these rocks accumulate in vast quantities on the side of a hill, literally paving it; then again, in long lines or rows as if they had been carried by swift water or dropped from an iceberg. Everywhere in the vicinity of the mountains are abundant indications that the last act in the drama was the existence of large bodies of water everywhere among the mountains, which must have come from the mountains themselves, inasmuch as the drift material indicates a local origin. We may suppose

that prior to the present period the temperature of the climate was very much lower; that vast bodies of snow and ice accumulated in the monoclinal portions of our continent, and as the climate became more mild, the ice and snow slowly melted, transporting icebergs filled with rock all over the plains, and when one of these vast icebergs would lodge and melt, the accumulations of worn rock and debris would be great. In almost all cases the slope of the hill opposite the mountain range is the one covered with the debris, as if the mass of ice in floating down, passed over the summit of the ridge and lodged on the opposite side. But it would be impossible for us to linger in all these pleasant places; entire volumes could be written illustrating the details of the geology of these plains; our only object is to gather along our route such facts as will illustrate our photographic views and link our story together.

Before we again start on our way westward, we ought to take a glance at the North Park, which is only about 50 miles to the southwest of Fort Sanders. The journey is quite easily made in two days, and even in one day on horseback, which is by far the best method of traveling in this mountainous region. In August, 1868, I made a tour to the North Park with a small party of army officers, and I shall not soon forget the scene of beauty that was opened to my vision from the summits of the mountains surrounding the park. I was the more desirous of visiting this region because so little was known in regard to it, and, although my visit was short and my examinations necessarily limited, I had the satisfaction of giving to the world the first accurate knowledge, ever obtained by personal investigation, of the geology of that interesting region.

Our course from Fort Sanders was nearly southeast up the Big Laramie River toward its source in the mountains. The geology of the plain country through which the Big Laramie flows is very similar to that of the Little Laramie—about 15 miles to the westward. There are comparatively few exposures of the basis rocks on account of the superficial drift which covers all this country. Still we find along the banks of the river, near the stage station, the same black plastic clay with *Ostrea congesta* and a few remains of fishes; also the chalky marls, and about two miles above, the long high ridges, on either side, extending up for several miles, composed of the rusty yellow sands and sandstone of the Lower Cretaceous. The dip of these beds is very gentle, hardly perceptible to the eye.

The Big Laramie is a very clear stream, about 50 yards in width and averaging about two feet in depth, easily forded in most places. Like most of the Western streams, the difference between high and low water mark is very great. In spring and early summer, when the snows of the mountains melt, these streams become formidable rivers. The soil along the bottoms appears to be very good, the grass grows quite heavily and hundreds of tons of hay are cut here by the settlers for winter use. The grazing is excellent, and numerous ranches have been started all through the valley for the purpose of raising stock. Even at this season of the year a great variety of flowers covers the surface. The *Compositæ* and *Leguminosæ* prevail in numbers, and yellow is the dominant color. As we approached the foot hills of the mountains the transition beds appeared on the ridge, rocks of more recent date having been swept away by erosion. Fragments of pudding stone and rusty colored masses of sandstone were scattered here and there; then beneath them were exposed about 400 feet of variegated arenaceous layers of uncertain age, perhaps Jurassic; then a little higher up the side of the mountains were revealed the red beds 1,500 feet or more in thickness, presenting wonderfully picturesque scenery. All these beds seem to have been lifted up in a nearly horizontal position, so that they present lofty escarpments, sometimes cone-like or pyramidal in shape, revealing each layer in the order of succession. The harder layers, yielding less readily to atmospheric influences, project out from the sides, adding much to the novelty of the view. Most of the beds incline from the flanks of the mountains at various angles, 3°, 8°, 15°, and then continue along the river, winding for 25 miles among the mountains almost to the foot of the snow-covered peaks.

On either side can be seen a number of sienitic nuclei, but I did not find the unchanged rocks so clearly in contact with them that I could define their relation to each other.

Before reaching the mountains, we passed a series of alkaline lakes which are simply shallow depressions, receiving the drainage of a small area without any outlet. From these shallow lakes the water is evaporated, so that in the autumn the bottoms are dry and covered with a white incrustation which looks much like water in the distance. One of these lakes still contained water and seems to have a fair supply at all seasons. It is almost a mile in length and half a mile in width. In the spring these lakes are quite large and are filled by the overflow of the branches

of the Big Laramie, which are greatly swollen by the melting snows. Great quantities of fish are swept into these lakes from the neighboring streams, and in the autumn the water becomes so alkaline by evaporation that the fish die in great numbers along the shore. It is a curious fact that not a single trout has ever been taken in any of the branches of the North Platte, unless a few have been caught in the Sweet Water, while the branches of the South Platte are filled with them.

After entering the foot hills of the mountains, the Big Laramie and its branches wind their way through the narrow valleys or gorges formed by the anticlinals and synclinals, produced by the upheaval of the unchanged rocks.

All the lower beds are more or less arenaceous and of a brick-red color, with only three layers of a light gray sandstone. No fossils can be found in any of the rocks, so that it is difficult to determine their age with certainty. We believe that the lower beds are Carboniferous, and have received their red color from the fact that the sediments were doubtless derived from the disintegration of the red sienitic rocks upon which they rest. It is also quite possible that a portion of the red beds are Triassic, and also that the yellow, gray and rusty sands and sandstones above are Jurassic.

Lying above the supposed Jurassic and beneath the well defined Cretaceous there is a large thickness of sandstone which I have called Transition beds, because they occupy the position of the lower Cretaceous, as shown on the Missouri River and in Middle Kansas. These beds are well developed and quite uniform in their lithological character all along the mountain sides from latitude 49° to the Arkansas, yet they have never yielded a single characteristic fossil that would determine their age. I have, therefore, called them provisionally Lower Cretaceous, or beds of transition from one great period of geological history to another, and the characters of the sediments which compose them justify the name.

Near our camp on the Big Laramie, which was about 35 miles southwest of Fort Sanders and about 15 miles above the foot of the hills, were some singular illustrations of the dynamics of geology. On the southwest side of the stream and inclining eastward or southeastward the entire series of red and variegated beds are shown in their order of succession 1,500 to 2,000 feet in height. At the foot of this escarpment is a low ridge of the red material, which is so grassed over that the

connection cannot be seen with the sienite nucleus. This covers a belt of sienite, about 200 yards wide and three to five miles long, the jagged masses of rock reaching a height of 1,000 feet or more, and standing nearly vertical or dipping slightly to the southeast. Between the sienitic beds and the river are the two low ridges of Cretaceous No. 2 and 3 which seem to have been lifted up with the sienite, but to have fallen back past a vertical position, so that they now incline from the sienite ridge, while on the opposite side the beds have a regular dip from the ridge. This peculiarity seems to be common in various localities, owing to the fact that the metamorphic beds which composed the central portion of all the mountains had suffered upheaval prior to the deposition of the unchanged beds. Therefore, in the quiet elevation of the mountain ranges the beds are merely lifted up in the direction of the dip of the older rocks, while they are, as it were, pushed away from the opposite side, forming what may be called an abrupt or incomplete anticlinal.

On the opposite or south side of the river there is a gradual slope of 2,000 feet above the bed of the stream, the strata inclining 5° until we reach the nucleus of another mountain range; so that we have here, as it were, two huge monoclinals. These monoclinals form local anticlinals, inasmuch as, in some places, all the beds incline for a short distance from a common axis.

On the north side of the river, and east for 10 to 20 miles, the flanks of the mountain ranges are covered with the unchanged rocks, which give comparatively gentle grassy slopes, owing to the readiness with which they yield to atmospheric agencies. Through these slopes many little streams cut their way, forming huge cañons, which exhibit along their sides the series of beds in their order of succession.

From a point near the source, for 20 or 30 miles, the river flows through a synclinal valley, the conspicuous red beds dipping from either side. Along the valley of the river are marked deposits of drift, the result of glacial action; but the most beautiful feature is the well defined terraces, about 50 feet high and smoothed off like a lawn. These terraces are covered with a considerable deposit of drift; but when they are cut through by streams the basis rocks are shown.

The scenery on either side of this valley is beautiful beyond description. On the west side are the snow-clad peaks of the Medicine Bow range in the distance, with numerous intervening lower ranges ascending

like steps. The snowy mountains are mostly destitute of vegetation and are covered with eternal snow, but the lower mountain ridges are covered mostly with what may be called groves of pine. Indeed, the pine groves and grassy openings are so arranged and proportioned, that the whole scene appears as if it might have been partially the work of art, and the traveler imagines himself in a sparsely settled mountainous district instead of the unexplored Rocky Mountain region. These openings and grassy slopes will make excellent pasture grounds, for the grass is good, and they are watered with the finest of mountain streams and springs. I would again remark that the pine forests of these mountains must at some period be an object of earnest pursuit. Even now the mountain sides are full of tie cutters, who cut and float hundreds of thousands of ties down the mountain streams 50 to 100 miles to the Union Pacific Railroad, whence they can be transported by railroad to any desired point.

In the moist ravines of the mountain sides are patches of the aspen *Populus tremoloides*, which from their peculiar mode of growth, form a striking feature in the landscape. They grow very thickly, seldom attaining a height of more than 40 or 50 feet, and not more than 12 to 18 inches in diameter. The bodies are very smooth and nearly white, and their tops form a rounded cone-shaped mass of foliage. These aspen groves are the favorite resort of deer, elk, grouse and all kinds of game.

On the east side also is the snow-clad range, which in its southward extension includes Long's Peak and numerous other peaks in the vicinity. On either side of these lofty ranges, which often rise above the limit of vegetation, are a number of successive lower ridges which descend like steps. There is such a wonderful uniformity in the structure of the mountains that a detailed description of a portion applies for the most part to all.

Our course along the Cherokee Trail was about southwest from the Big Laramie River, over ridge after ridge, and after traveling 25 miles, we entered the North Park through some of the most beautiful scenery of that interesting region. From the summit of the high ridges on the north we looked to the southward over a series of lofty cones or pyramids, as it were, all clothed with a dense growth of pine. The metamorphic rocks of which these mountains are composed disintegrate so easily that the surface is covered with a deposit of loose material, as fine earth and fragments of rock. The hills have, therefore, been so smoothed down

that it is difficult to see the basin rocks in continuous lines. We saw enough, however, to show us that red sienite in its various forms constitutes the principal rocks, while now and then a bed of hornblendic gneiss, white quartz or greenstone, occurs. All through the mountain region are small open areas, sometimes on the hills and sometimes on the lower ground, forming meadow-like spots which the various kinds of animals love to frequent, to feed on the abundant grass. The Old Cherokee Trail derives its name from the fact that a party of those Indians cut their way through the thick pines, about 30 years ago, with a train of 300 wagons.

The traveling was difficult at this time, owing to the ruggedness of the surface and the obstruction from the fallen pines.

So far as I could ascertain it, the trend of the upland mountain ridges of sienite is nearly east and west, and the dip nearly north. The North Park is oval or nearly quadrangular in shape, about 50 miles in extent from east to west, and 30 from north to south, occupying an area of about 1,500 square miles. Viewed from one of the high mountains on its border, it appears to be a vast depression which might once have formed the bed of a lake. Its surface is rather rugged, yet there are broad bottoms along the streams, especially the North Platte and its branches. Scarcely a tree is to be seen over the whole area, while the mountains which wall it in on every side are dotted with a dense growth of pine. The grass grows in the park quite luxuriantly, often yielding two tons of hay to the acre. Streams of the purest water flow through it, a few of them forming good sized streams where they issue from the ground, and I am quite confident that this entire park would make an excellent grazing region for at least six or eight months of the year. Myriads of antelope were quietly feeding in this great pasture ground, like flocks of sheep. The soil is very rich, but the seasons are too brief for the successful cultivation of any crops. Indeed, there is frost here nearly every night, and snow falls every month of the year.

As I have before stated, the park is surrounded with lofty ranges of mountains as by gigantic walls. On the north and east side may be seen the snow-covered ranges rising far above all the rest, their summits touching the clouds. On the west side there is also a short snowy range. The snowy ranges on its east border have their north sides abrupt, the south sides are less so as seen from a distance, and the massive rocky

lower hills appear inclining southward. All along the north side the hills incline southwestward, while the higher ranges are quite steep, and correspond in the apparent dip of the beds to the lofty snow-clad mountains on the east which incline south or southwestward. The inclination of the metamorphic beds composing the higher ranges, is from 60° to 80°. On the west side of the park long ridges seem to slope gradually down, so that they die out in the plain, forming a sort of *en echelon* arrangement. It is due to this fact that the area enclosed receives its oval shape.

The general trend of all the continuous mountain ranges is nearly northwest and southeast on all sides, but there are many local dips and variations from this direction.

I was much interested to know whether any of the unchanged rocks, which are so well developed in the Laramie Plain, occur in the North Park. I found that the entire series of red and variegated beds, including a portion of the Cretaceous strata, were fully represented, all inclining from the flanks of the mountains and gradually assuming a horizontal position, or nearly so, toward the central portion of the park. The transition beds or Lower Cretaceous form quite conspicuous ridges, inclining 19° to the southwest. They are composed of a very beautiful pudding-stone of small rounded pebbles, most of them flint, cemented together with a silicious paste. On the north side are quite large areas covered with loose sand, which is blown about by the wind, resembling the sand hills on the Niobrara River. A close examination of the sand shows that it is composed mostly of worn particles of quartz and feldspar. The surface contains little or no vegetation, presenting a peculiar barren appearance, the sand moving readily with the wind.

Hitherto it has been impossible to color on any geological map the geological formation of any part of this mountain region, and no information has ever been given in regard to the structure of the North Park. It will be impossible even now, with the imperfect topography of any of the maps, to color the geology in detail, but these explorations will enable a geologist to fix the outline of the formations in a general way, with a good degree of accuracy.

During the summer of 1868, an excitement was created at Laramie City by the supposed discovery of rich placer mines far up in the mountains, near the Snowy Ranges, to the southwest of the plains. A

large party was formed at Fort Sanders, directed by Generals Gibbon and Potter, of the United States Army, and accompanied by Professor James Hall, of New York, to visit the region and ascertain the truth of the reports. The time was most favorable, in midsummer, when the mountain vegetation presents a spring aspect.

Camping with our wagons at the base of the main range of mountains, near the source of the Little Laramie, we prepared to ascend the mountains on horseback to the gold mines. We rode a distance of about 10 miles before we came in view of the "diggings," and to reach them made an ascent of about 2,000 feet above the bed of the creek. We were then between 10,000 and 11,000 feet above the sea, very near the elevation of perpetual snow and where frost occurs every night of the year. On the summits of these lofty mountains are some most beautiful open spots without a tree, and covered with grass and flowers. After passing through dense pine forests for nearly 10 miles, we suddenly emerged into one of these park-like areas. Just in the edge of the forest which skirted it, were banks of snow six feet deep, compact like a glacier, and within a few feet were multitudes of flowers, and even the common strawberry seemed to flourish. These mountains are full of little streams of the purest water, and for six months of the year good pasturage for stock could be found.

The gold is sought after in gulches, formed by the little streams that flow from the Medicine Bow and other snowy mountains, most of which empty into the North Platte. We labored for two days to discover the quartz seams, which we supposed to be the source of the stray lumps of gold, but the great thickness of superficial drift, which covers all these mountains, concealed them from our view. The gold as far as known in this district, seems to be confined to the lower glacial drift. That valuable mines will be found in these mountains at no distant day seems very probable. The geological evidence is quite conclusive, and the mountains are a continuation northward of the same range, in which the rich mines of Colorado are located.

Not only in the more lofty ranges, but also in the lower mountains are large forests of pine timber, which will eventually become of great value to this country. Vast quantities of this pine in the form of railroad ties are floated down the various streams to the Union Pacific Railroad. One gentleman alone has a contract for 550,000 ties, all of which he floats from the mountains along the southern side of the Laramie Plains.

The Big and Little Laramie, Rock Creek and Medicine Bow River with their branches, are literally filled with ties at this time, and I was informed, that in time of high water they can be taken to the railroad from the mountains, after being cut and placed in the water, at the rate of from one to three cents each. These are important facts, inasmuch as they show the ease with which these vast bodies of timber may be brought to the plains below and converted into lumber, should the future settlement of the country demand it.

There are several species of pine wood and one spruce or balsam fir, *Abies Douglassi*. The latter is a beautiful and symmetrical tree, rising to the height of 100 to 150 feet and as straight as an arrow. The ties that are made from this spruce are of the best quality.

We will now return to Fort Sanders, and continue on our westward way. From Fort Sanders to Cooper's Lake Station the distance is about 28 miles. On our right hand we can see, with great distinctness, the Laramie Mountains as they flux around westward, preserving a remarkably symmetrical appearance. A heavy bed of limestone, which appears not to have suffered greatly from erosion, covers the flanks high up to the margins of the summit, and seems to have protected their rounded sloping form. Here and there may be seen a deep gorge cut through at right angles by some little stream, that has its source in some spring on the summit. Along the base of the mountains on the east side of the road, patches of the brick-red beds are very abundant, giving a picturesque appearance to the view. After crossing the Big Laramie the surface is quite uniformly level or rolling, and covered with thick grass or sage. The country is underlaid with Upper Cretaceous rocks, and possibly in some places there may be small patches or remnants of Tertiary beds. We seem to be gliding along over a nearly level, monotonous country, with scarcely anything to intercept the vision. Far to the westward the dim outlines of the Medicine Bow Range can be seen, reminding us that we are walled in by lofty mountains. But the road is fine, and sometimes for long distances the track seems as straight as an air line. These broad, grassy plains are not yet entirely destitute of their former inhabitants; flocks of antelope still feed on the rich nutritious grasses, but the buffalo, which once roamed here by thousands, have disappeared for ever. No trace of them is now left but the old trails which pass across the country in every direction, and the bleached skulls

which are scattered here and there over the ground. These traces are fast passing away. The skulls are decaying rapidly, and this once peculiar feature of the landscape in the West will be lost. Two years ago I collected a large quantity of these bleached skulls and distributed them to several of our museums, in order to insure their preservation.

There is also a singular ethnological fact connected with these skulls. We shall observe that the greater part of them have the forehead broken in for a space of three or four inches in diameter. Whenever an Indian kills a buffalo he fractures the skull with his tomahawk and extracts the brains, which he devours in a raw state.

Indians or old trappers traveling through the enemy's country, always fear to build a fire, lest the smoke attract the notice of the foe. The consequence is, that they have contracted the habit of eating certain parts of an animal in an uncooked condition. I have estimated that six men may make a full meal from a buffalo without lighting a fire. The ribs on one side are taken out with the knife and the concavity serves as a dish. The brains are taken out of the skull, and the marrow from the leg bones, and the two are chopped together in the rib-dish. The liver and lungs are eaten with a keen relish, also certain portions of the intestines, and the blood supplies an excellent and nutritious drink. Both, Indian and buffalo, have probably disappeared for ever from these plains. Elk, black-tailed deer, red deer, mountain sheep, wolves and the smaller animals are still quite abundant, especially in the valleys of the small streams, where they flow down through the mountains; Elk Mountain and Sheephead Mountain have always been noted localities for these animals.

The traveler will have his attention called to Carmichael's Cut, an excavation through the arenaceous clays and sandstones of the Upper Cretaceous deposit, which has become noted for the wonderful fossils found there. Baculites, Ammonites, Inocerami, and a great variety of marine shells, glistening with the iridescent hue of mother of pearl, are found in aggregated masses, as if this had been a portion of the Cretaceous sea. Farther on at Miser Station these beautiful fossils occur again in the greatest abundance, and thousands of them have been gathered and carried away by curiosity seekers. Near Medicine Bow the Lower Cretaceous clays prevail, and in the hills bordering the Medicine Bow Creek a large singularly tuberculated ammonite is found associated with a species of

Scaphites or boat-shaped shell, looking very much like a large worm coiled up, and hence its name, *S. Larvæformis*. These shells have received all sorts of names in the country, and the most wonderful tales are related of petrified snakes, etc.

Many years ago, when I was attached to a military expedition on the Yellowstone River, our party came to a most remarkable locality for these peculiar fossils. They were enclosed in concretionary masses of blue limestone, and when the soldiers were knocking out these small Scaphites with a row of tubercles on each side of the back, they pronounced them with most emphatic authority to be tobacco worms. The Baculites, Ammonites, Scaphites and the great variety of chambered shells belong to a group that is now extinct, though most abundant in ancient times. Already as many as 1,200 species have been described by paleontologists, and it is probable that at least as many more will be found, and yet the only remnant of that great family living in our present seas is comprised in five or six species of Nautilus. More than forty species of fossil Nautilus have been found and many more will be discovered.

All over this Rocky Mountain region from the Arctic Circle to the Isthmus of Darien, these remarkable marine shells are found and in some instances upon the summits of the loftiest ranges.

The valleys of the Upper Missouri and Yellowstone Rivers have already yielded nearly 400 varieties of these sea-shells. We have therefore the most ample evidence, that in past geological times the great ocean rolled all over the area now occupied by the mountain ranges.

After passing Cooper's Creek Station we come into the black clays of the Lower Cretaceous, and the appearance of the country becomes dreary and sterile in the extreme. The waters are alkaline, and there is no timber along the creeks except stinted willows, and very little grass or vegetation except chenopodiaceous shrubs, which are fond of this alkaline soil. As far as the eye can reach nothing can be seen but these sombre, plastic clays. The surface also presents the characteristic monotonous appearance, which is common wherever these clays prevail. Six miles before reaching Como, we come to an interesting quarry of sandstone, from which the materials for the construction of the extensive railroad buildings at Laramie City and Cheyenne are obtained. The rock is gray, coarse and friable, and one would suppose not durable enough for such important structures, but it is easily wrought into any determinate form. This is a locality

to which I call the special attention of the geologist as one in which there is an interesting problem to work out, viz.: what is the exact position of this sandstone in the geological series. It is filled with fragments of vegetable impressions, with sometimes quite distinct deciduous leaves, much like those already noticed in chapter II., as occurring at Blackbird Hill, on the Missouri River. The leaves of the willow and poplar are quite distinct, reminding one of those growing along our little streams at the present day, and yet they are all of extinct species. These sandstones are local and seem to have been deposited over a small area, inasmuch as they occur nowhere else on the plains, so far as I have observed.

The black shales filled with remains of fishes and marine shells occur above and below the sandstones, showing very clearly that they are of Lower Cretaceous age. Still it would be a matter of interest to attempt the construction of the physical conditions, which were necessary in those old Cretaceous times, myriad of ages ago, for the ocean waters to deposit such an accumulation of sandy material in this locality. The scenery is somewhat changed also, the little stream which cuts through the rocks, flows through vertical walls of the sandstone 100 to 200 feet high.

Farther on toward Como, we see on our right hand the brick-red beds which are so common along the slopes of the first range. At Como Station, the road runs through a curious anticlinal valley, the strata inclining in opposite directions about northeast and southwest. The southwest side displays the most complete series of the beds. They are composed for the most part of alternate layers of sands and some harder beds of sandstone, but there are a few of these beds of marl, or limestone, in which are found great quantities of fossil shells, *Ostrea Pentacrinus*, *Astersicus* and *Belemnites densus*. The oyster is a very small one; the star-fish is very beautiful but imperfect; and the *Belemnite* or ancient cuttle-fish is more abundant and more characteristic than the others. They are all of well known Jurassic types. All around the shores of the pretty little lake thousands of these sharp pointed *Belemnites* have been gathered and given to travelers. These fossils are very abundant in some parts of Europe, where they are called "Ladies' Fingers," from their long slender, symmetrical shape. These fragments are all that remain of an animal that was probably quite large and complicated in its structure, much like the cuttle-fish of our present seas. It undoubtedly had the power to secrete a black liquid, a sort of ink or sepia, which it

could emit at pleasure, and thus provide a place of concealment when pursued by foes.

There are other attractions here, of which the traveler will be informed long before he reaches the locality. The "fish with legs" are the only inhabitants of the lake, and numbers of persons make it a business to catch and sell them to travelers. During the summer season they congregate in great numbers in the shallow water among the weeds and grass near the shore, and can be easily caught, but in cold weather they retire to the deeper portions of the lake and are not seen again until spring. These little animals are possessed of gills, and were it not for the legs, would most nearly resemble a miniature cat fish. But when warm weather comes, a form closely resembling them, but entirely destitute of gills, may be seen in the water swimming, or creeping clumsily about on land. Sometimes they travel long distances and are found in towns, near springs or wet places, usually one at a time, while those with the gills are never seen except in the alkaline lakes which are so common all over the West. Professor O. C. Marsh, of Yale College, Conn., an eminent naturalist, while on an excursion along the line of the Union Pacific Railroad two years ago, observed a number of the gilled forms or Siredons, and taking them to New Haven, watched their remarkable transformation into the more mature condition without gills. These animals belong to the family of *Salamanders*, a group allied to the frogs, and the first form bears about the same relation to the last, that the tadpole does to the mature frog. Professor Marsh's very interesting and detailed account of these singular animals can be found in the "American Journal of Science," for November, 1868, and from his article I have taken the following extracts:

"The first indications of any change were observed in one of the smaller specimens, about six inches in length; and the metamorphosis had apparently commenced during the journey from Lake Como to New Haven, which lasted about a week. Small round spots of dark brown were first noticed on the sides of the tail, and the color of the entire animal gradually assumed a darker hue. The broad thin membrane along the back, and above and below the tail, gradually began to diminish by absorption, the external branchial appendages soon became similarly affected, especially at the ends, and the animal came more frequently to the surface of the water for air. As the change went on, the dark spots

increased in number and size, and gradually extended over the whole upper part of the body. The membrane on the back and tail entirely disappeared, leaving in its place in the dorsal region a sharp groove. The branchiæ also continued to diminish, and at the same time the internal branchial arches began to be absorbed, and shortly after the openings on the neck closed up. In the meantime the head became more rounded above, and more oval in outline, the muzzle narrower and more pointed, and the eyes more convex and prominent. The body also decreased in bulk, and the costal grooves became more distinct. The thin external skin was shed, and the secretion of mucus from the surface sensibly diminished. During these changes the animal showed an increasing desire to leave the water, often remaining for some time with its external nostrils above the surface, and occasionally making violent struggles to escape. Aided by a heavy rain at night it at last succeeded, and thus put an end to farther observations, just at a time when it had lost the generic characters of *Siredon*, and become a true *Amblystoma*, two forms of Batrachians usually regarded hitherto as belonging to distinct families.

"Fortunately, a few days later, several other specimens of various sizes began, nearly at the same time, to show unmistakable indications of a similar transformation, and this afforded an opportunity of noting the successive phases of the change more fully, as well as of observing the physical conditions which seemed to promote or retard it. Two of the specimens were placed in a glass jar, and left in a strong light, and five others were kept in a cooler place in the shade, the temperature of the two, however, differing but a few degrees. At the end of three weeks those in the glass vessel had apparently completed their metamorphosis, while of the others less favorably situated three only were partially altered, and at the present time, or nearly three weeks later, they still retain tubercular remnants of the external branchiæ, although in most other respects the change appears to be complete. The two remaining specimens, however, which had throughout been kept with the three last, showed no distinct signs of changing, although the probability of their doing so, and the importance of retaining some tangible evidence of the original condition, led to the transfer of one of them to a jar of alcohol after the first week, a precaution, as the result showed, quite unnecessary in the case of the other, which at the time of writing (Octo-

ber 5th) still remains a typical Siredon, with no alteration more important than a single appearance in a new epidermis."

Similar observations had already been made by a celebrated French naturalist, Professor Dumeril, on an allied species, found on the table-lands of Mexico; and it was a matter of no small interest to Professor Marsh to ascertain whether this species would undergo a similar change when placed under different physical conditions, hence these creatures were watched with great care.

"Among the other more important changes which occurred during the metamorphosis may be mentioned the decrease in the size of the entire body, which was very marked, a perceptible increase in the distinctness of the costal grooves corresponding to the vertebræ, and the gradual ossification of the carpus and tarsus. The feet also became less palmate, and the toes less depressed. During the transformation, moreover, and especially after its completion, all the specimens shed the thin, transparent epidermis, some of them very frequently; one, indeed, which had been kept in a strong light, lost this covering three times in the ten days immediately following the metamorphosis.

"The change in the habits of the Siredon in passing into the Amblystoma state was scarcely less marked than the alteration in its physical characters. As soon as the absorption of the external branchiæ commenced, the animal came more frequently to the top of the water and took a mouthful of air; and not long afterwards would occasionally float for some time at an angle of about 45°, with the external nostrils above the surface. Frequent efforts to leave the water soon followed, and an opportunity of so doing was in most instances speedily improved, and the change then seemed to progress more rapidly. One or two specimens, however, showed for some time, especially in cool weather, much less inclination to desert their native element, apparently suffering little or no inconvenience from remaining under water, if allowed to come to the surface about once in five minutes. The pugnacious propensities of the Siredons, which at first led to occasional assaults on one another, appeared to diminish as the change progressed, and the more sluggish nature of Salamanders at last predominated; although the altered forms at times showed no little celerity of movement, and when irritated, especially when held by the tail, would often turn and snap at the hand with a rapidity that would have done no discredit to a reptile of much higher organization.

"The effect on the metamorphosis of a variation in light and temperature has already been alluded to. During a succession of very warm days, about the first of September, the change progressed with great rapidity, but it apparently ceased, or made very slight progress, in the cool week that followed. While, moreover, the two specimens most favored in regard to light and warmth passed apparently through the entire transformation in about 20 days, those which commenced at the same time, but were less favorably situated, required at least twice that time for its completion. The only living specimen still remaining unchanged, has twice shown slight indications of an approaching metamorphosis, but with the exception of some spots, these have apparently soon disappeared after a transfer to a dark and cooler place."

As we pass on westward we come into the eastern border of the great coal fields of the Rocky Mountains, and inasmuch as they are of vast importance to this great thoroughfare, as well as to the country, I will make them the subject of the next chapter.

CHAPTER V.

WESTWARD TO BEAR RIVER.

SOON after passing Medicine Bow Station, the dark, sombre appearance of the surface of the country ceases, and the more cheerful aspect produced by the overlapping of the Tertiary beds is seen. We move on rapidly through inclined ridges of sandstone and shaly clays, dipping westward from 30° to 50°. Here we begin to discover indications of coal in the black bands of Carbonaceous clay that crop out on either side of the road. But the most marked development of the coal beds will be observed at Carbon Station, about 800 miles west of Laramie. The first openings were made about 300 yards from the railroad track, where a bed of coal was discovered nine feet in thickness. The demand for the coal was such that it was thought advisable by the company to sink a shaft close by the track, and now the coal is taken out in large quantities daily for the use of locomotives. A thriving little town has been built up here by the coal trade alone.

The coal which is taken out of this mine is of the best quality of the Tertiary brown kind, and is very compact and pure. It is not as hard as anthracite, but the miners informed me that it was more difficult to work than the bituminous coals of Pennsylvania. The engineers speak in high terms of it as fuel for locomotive use.

Just over the coal is an earthy bed, of what the miners call "slate," which breaks into slabs, showing a woody fibre, and much of it looks like charred wood or soft charcoal. A little higher up, we find thin layers composed almost entirely of fragments of deciduous leaves, and above these come various kinds of clays and sands. Beneath the coal there are

indurated clays and rocky strata in which occur thousands of impressions of leaves much like those of our common forest trees, but belonging to species long since extinct. They belong, however, to genera such as *Populus*, *Platanus*, *Tilia*, with many others, most perfectly preserved, and all plainly pointing to a period far back in the geological past when these vast, treeless regions of the present time were covered with dense forests, surpassing even those now growing in Ohio and Kentucky. Some of the layers of rock, two to four inches in thickness, are almost entirely made up of these leaves, and the condition in which they have been preserved shows that they could not have been transported any distance, but must have fallen from trees that grew in the vicinity. Indeed, there is no doubt, for myriads of ages in the past, gigantic poplars, sycamores, lindens, oaks and others spread their broad branches over the shores of some little streams or lakes, and shed their foliage in the shallow waters in the same manner as they do at the present day. In the autumn, I have seen the sandy bottoms of the little streams that flow into the Missouri and Yellow Stone Rivers filled with the leaves of the cotton wood and elm in a perfect state of preservation, and had the conditions been favorable for compacting these sediments into rocky layers, the geologist might have split them open with his hammer, and revealed the leaf impressions as perfectly preserved in every part as if they had been carefully pressed in a ladies' herbarium. The traveler will find it profitable and instructive to remain at this locality a day.

The coal is not confined to the neighborhood of the road. It crops out in many localities for 20 or 30 miles on either side, so that we see there is an abundant supply of fuel stored away for future use beneath this apparently barren surface. When we reflect that nearly all the wood or timber that is used along the line of the road has to be transported a distance of 20 to 40 miles, and that even this scant supply will be exhausted within a few years, we shall at once arrive at the conclusion that the future success of this great thoroughfare is entirely dependent on the supply of mineral fuel, and that its importance for all time to come cannot be too highly estimated.

The coal formations extend along the line of the road to St. Mary's Station, a distance of 25 miles west of Carbon; from thence, to Rawlins Springs, about 30 miles, the road passes over strata which are mostly of Cretaceous age. To the geologist this entire region is one of great interest.

Even up to the present time it is invested with much obscurity. Probably no rocks older than Cretaceous or Tertiary occur; but the beds are so complicated by the forces that have elevated the neighboring mountain ranges, that it is difficult to unravel their relations.

Soon after leaving Carbon, we pass through several cuts which show the strata, sometimes inclining nearly west, and soon again in the opposite direction. We seem to be continually passing across a series of anticlinal and synclinal axes. Just before reaching the North Platte River we pass along the valley of one of the most remarkable anticlinals in the West. On either side of the road, the rusty gray sands and sandstones incline at an angle of 10° to 15°. The strata rise like walls on both sides to the height of 700 or 800 feet in graduated ridges or steps. I have been informed that thin beds of coal have been discovered within a few miles of Fort Steele; if this be so, they must occur high up on the summits of these ridges. Near the bridge over the North Platte, the black plastic clays of the lower Cretaceous are distinctly seen, but following up the exposed edges of the inclined ridges, we find an Oyster and an Inoceramus which are peculiar to the upper Cretaceous beds. Passing up still higher, we shall discover thin layers made up wholly of a small species of Oyster which seems to be characteristic of what I regard as transition or beds of passage between the strictly marine sediments of the Cretaceous era, and the brackish and the fresh water which characterize the Tertiary period.

We can see here a marked instance of a valley of erosion or a long natural opening, as if prepared in ages past for the passage of the road. We can reflect with what ease comparatively, it has been constructed across what would seem to be an impassable country, by following the water courses and their valleys of erosion, admiring the energy and consummate skill of the engineers who first located the road through this wild and rugged region.

We have not alluded to the scenery in this vicinity from the fact, that to the ordinary traveler there is little that is attractive. To most persons the whole country would appear like a barren waste. But if we look far away southward toward the sources of the North Platte in the North Park, we shall see some lofty ranges of mountains with peaks that loom up in solitary grandeur. Elk Mountain is a noted landmark, and seems to rise out of the plain as if it was an isolated peak. It is, however, a portion of the Medicine Bow range, partially cut off from the northern

end. It is surrounded by rolling prairie which is covered the greater portions of the year with splendid grass. Hence all the river valleys in this portion of the mountains have been noted places for game of all kinds, as elk, deer, mountain sheep, etc. Fabulous stories are also told of the mines of gold and silver which have been discovered. As yet the geology is little known. The sides of these mountains are covered with dense forests of pine, spruce and hemlock; and during the construction of the railroad, thousands of ties were floated down the branches of the North Platte into the main stream and thence taken to their destination. The little streams that flow from the mountains have in many places quite broad valleys, which afford an abundance of hay and pasturage for all kinds of animals, wild and domestic. The wild animals often descend into the beautiful grassy bottoms to feed in large herds, and at the least approach of danger, retire to the almost inaccessible ravines and gorges of the mountains. The big horn, or mountain sheep, may often be seen in flocks, peering from some mountain peak upon the traveler below. Early in the morning, these animals descend into the valleys to crop the moist grass, but during the greater portion of the day they will be found, if discovered at all, upon the most precipitous crags and ridges of the mountains. The little streams are full of fine trout, which are easily caught, they not having learned as yet the cunning arts of self-protection, like their eastern relatives. These ravines and gorges afford most excellent shelter, both for Indians and animals, during the cold season of winter. The close proximity of this delightful region to the railroad, must make it a desirable place of resort for sportsmen during the summer.

There is another interesting feature connected with the North Platte and its tributaries, as well as with most of the mountain streams, to which I would call the attention of the inquiring traveler; and that is, the abundant signs of the existence of that most sagacious animal, the beaver. These mountain streams seem to abound with them at the present time, and their dams are very numerous, not unfrequently producing a rise of the water, three to five feet. Extensive dams and ponds are caused by these industrious animals, and sometimes quite large areas in the valleys are overflowed, rendering the crossing difficult and dangerous. They sometimes strip off the usual fringe of cotton wood and willows along the streams so completely, that they are obliged to emigrate to some other locality to secure food and materials to repair their dams.

Not far from Fort Steele may be seen at this time, cottonwood trees 18 and 20 inches in diameter, which have been cut down by them, and I have seen stumps in the valley of the Yellowstone 30 inches in diameter. Their fur is of so little value at the present time that they are not much sought for by trappers or Indians.

Two miles west of Fort Steele is a station, or side track, called Benton, which was a town of 3,000 inhabitants about two years ago. It is hardly possible to believe that in so sterile and waterless a place, so large a number of people could have existed, as all the fuel and water used by them had to be transported several miles. The remains of these temporary cities are scattered all along the line of the railroad, and the scenes of savage barbarity, which were connected with them, have all passed away, and it were well if they could be forgotten. If we go a little way into the hills, not far from any of these old town sites, we shall find a cluster of graves, every one of the inmates of which perished by violence.

The Cretaceous formations continue to give the dark, sombre aspect to the surface as far as Rawlins Springs. This is a growing village, and was named in honor of the lamented General John A. Rawlins, our late Secretary of War. The traveler will find here one of the finest hotels on the route with excellent accommodations. A round-house and machine-shop, with other important buildings, have been erected by the railroad company, and these form the nucleus of the village. The elevation above tide water is 6,540 feet.

At this locality the geological features are very interesting, from the fact that the elevatory forces were exerted more powerfully than at any other point along the road from Laramie to Green River. The entire series of rocks known in this country are exposed here, from the red feldspathic granite to the Cretaceous, inclusive. The road passes through a very interesting anticlinal opening, which presents a fine example of the advantages which the skilful engineer may take of the erosive effects of atmospheric agencies in past geological times. There is here a lofty ridge or mountain extending nearly north and south, where it passes through an opening just wide enough for the track, while the walls of granite and quartzite enclose it on either side. No water being here at the present time, this opening was worn through by agencies not now in operation.

A fine sulphur spring which issues from beneath a bed of blue limestone, gives name to the station. The water is clear as crystal, and

possesses excellent medicinal qualities. About a mile north of the station there is another interesting sulphur spring, from which flows a volume of water sufficient to form a stream two feet wide and four inches deep. The water is clear and cool in summer, though it both tastes and smells strongly of sulphur.

South of the road can be seen beds of variegated, gray, brown and reddish quartzites, with a very hard, blue limestone resting upon them, which I suppose to be of Carboniferous age, though I could find no evidence from fossil remains. On the opposite side of the road the ridges of upheaval stretch far away toward the northwest, and rise to a height of 1,200 to 1,500 feet. Granites, sandstones and pudding-stones can be studied here to any extent, and the relations of the metamorphic with the sedimentary rocks are well exhibited.

All these ridges have suffered tremendous erosion, and the sandstones have been planed and grooved even to a greater extent than the more recent beds. Everywhere the evidences of erosion during the Drift period are shown on a gigantic scale.

Some very interesting specimens of native copper have been found in this ridge, which at one time produced no small degree of excitement among the inhabitants. The copper ore was found, on more careful investigation, to be of no special economic value. It seems to occur as a sort of chemical precipitate in the reddish Triassic quartzite near the summit of the ridge; sometimes it is diffused through the rock in green streaks in the form of green carbonate; with this last, large masses of calcspar are coated; there are also very pretty dendritic impressions. Near the copper mines are some heavy beds of red oxide of iron, which must at some period become of great value to the country. The beds are four to six feet thick, and though they appear to be local, yet a great amount of ore could be taken out at comparatively small cost.

It is an interesting fact that, although we are continually traveling across what is usually regarded as the summit of the great Rocky Mountain range, 6,000 to 7,000 feet above tide water, yet this is the only locality along the road, between the Laramie Mountains and the Wasatch Range, in Weber Valley, where we meet with rocks older than Jurassic, and, except for a few miles near Lake Como, none older than Cretaceous. Rocks of ancient date seem to be the exception, while those of quite modern age, geologically speaking, prevail.

If we continue our journey westward from this point, we shall meet with the coal strata again about four miles west of Rawlins Springs, in the form of uplifted ridges inclining westward, but by the time we have reached Creston all the beds have quietly settled down into a horizontal position. At Separation, ten miles from Rawlins Springs, quite extensive coal mines have been opened, with a bed of coal 11 feet in thickness. These coal beds undoubtedly form a portion of the great basin previously noticed at Carbon and other localities. On the summits of the hills above the coal beds are thin layers of calcareous sandstone, upon which may be seen impressions of leaves of the poplar, sycamore and other forest trees that once clothed this barren region in beauty and fertility.

The Tertiary beds lie in ridges running across the country nearly northeast and southwest, and are tilted in every direction. A more desolate region I have never seen in the west; nothing seems to flourish but the wild sage-bush, which in some places grows so large and dense as to render traveling difficult. All over the surface of the hills, as well as of the plains, there are great quantities of water-worn pebbles. Many of these valleys have been scooped out by a force and volume of water far in excess of any known at the present day in this region. Some of the wildest and deepest of the valleys do not now contain any running stream.

West of Separation, the rugged ridge-like character of the surface ceases, and on reaching Creston, 13 miles to the west, we shall find the strata nearly horizontal, and the country comparatively smooth and level. At Creston, the Union Pacific Railroad Company sunk a well 100 feet or more in depth; at 83 feet a bed of coal was found, about eight feet in thickness, and just over the coal was a layer of fine, bluish clay, in which was a great abundance of impressions of leaves of forest trees, most of which belonged to poplars and sycamores. The railroad cuts, as well as the valleys of the small streams, reveal very clearly the character of the intermediate softer beds. Here, on the summit of the Rocky Mountains, on the dividing crest where the waters flow eastward into the Atlantic and westward into the Pacific, we find a large area covered with very modern Tertiary beds, in an apparently undisturbed position. The erosion has been so great, and the planing and smoothing process so complete, that the surface is covered with debris to such an extent that it is almost impossible to obtain a clear idea of the color and composition of the basis rocks for any great depth. Still we know that

marine and fresh water Tertiary formations occupy the country for the most part to Quaking Ash Summit, and very largely to Salt Lake Valley.

From Creston to Bitter Creek Station, a distance of 45 miles, nothing remarkable meets the eye, but the general appearance of desolation. West of Bitter Creek Station, the coal formations again appear, inclining about east 3° to 7°. We have, therefore, between Rawlins Springs and Green River, a kind of synclinal basin, with the coal strata on either side elevated at different angles, and inclining in opposite directions, while in the central portions, from Creston to Bitter Creek, the beds are nearly horizontal and of quite modern age, containing purely fresh water and land shells, such as *Paludinas*, *Unios*, *Melanias*, *Helices*, etc. Most of the compact rocky layers are made up of an aggregate of shells, which are used as building materials, for the walls of houses, etc.

Table Rock is a square butte, which rises about 400 feet above the level of the road, composed of beds of Calcareous sandstone, for the most part a simple aggregate of fresh-water shells.

About two miles west of Creston, the traveler will observe a flagstaff, which marks the crest or dividing line of the great water-shed of the continent. Here in this desolate spot, with no mountain ranges in close proximity, without a tree in sight, or a shrub larger than the wild sage, without a drop of water within several miles, only the old dry beds that have been worn out by the melting of snows on either side of the dividing line, we stand on the summit of the great Rocky Mountains, 7,100 feet above tide water. It certainly requires a vivid imagination to be profoundly agitated by the scene.

Far in the distance on either side, ranges of mountains lift their rugged summits toward the clouds, and command a momentary respect. In the west the Sweet Water Range can be seen quite distinctly, the tops covered with snow the greater part of the year, while to the north the Seminole Mountains are visible. To the west and north the Wind River Range, which also forms a portion of the great water shed of the continent, can be seen, with its conical peaks above the clouds, 14,000 feet or more above the sea. Bridger Pass, which I had always pictured to my imagination as a gorge through lofty walls of granite, is nothing more than a slightly elevated ridge in a broad undulating plain. It is simply a portion of the crest or divide, and the mountains, which I had supposed formed the walls of the pass, are so remote on either side as to be scarcely visible.

After leaving Bitter Creek Station, we shall observe that the hills approach nearer to the railroad and reveal more clearly the characteristic features of the older marine or brackish water Tertiaries. Seams of coal crop out everywhere with bands of dark clay and yellow sand. We are descending the valley of Bitter Creek toward Green River, through one of those avenues excavated in geological times for a railroad, with high walls or bluffs of sandstone enclosing it on either side. These high sandstone bluffs or walls are nearly vertical in many places, and are weathered into most grotesque and amusing forms. "The tooth of time" seems to have been constantly at work gnawing into their sides, slowly and almost imperceptibly perhaps, yet the erosion which has been performed here will continually excite our wonder.

At Black Butte Station there is a thick bed of yellow sandstone full of rusty looking concretions of all sizes, from an inch to several feet in diameter, mostly spherical in form, and when broken showing large cavities filled with an earthy powder or oxide of iron. This sandstone forms nearly vertical walls or bluffs 150 to 200 feet high, and is worn by atmospheric agencies into the most peculiarly fantastic shapes. Above it are sands, clays and sandstones of every variety of texture, with coal beds, one of which, near the summit of the hills, has been burned out by ignition caused by the decomposition of iron pyrites, so that the superincumbent beds have been baked a brick-red color. This appearance, though common in the coal regions of the West, aids much in giving variety to the scenery. In the Yellow Stone Valley the hills present the appearance of the ruins of burned cities.

Photograph VIII. presents a fine example of these sandstone bluffs, with the evidence of the constant and slow wearing away of the sides by atmospheric influences. At the left, we see the valley of Bitter Creek, through which the road runs; at the extreme left are low, rather rounded hills, which gradually ascend for miles, so that they become eventually several hundred feet above the bed of Bitter Creek. It is very seldom that abrupt bluffs occur on both sides of a stream at the same locality except in the mountains where the little streams have cut their way through immense masses of rock, forming gorges or cañons. On the right of the picture, the hills ascend far to the north as before described. The coal beds which yield a supply of fuel for the road lie above and below this sandstone.

The tendency of this sandstone to weather into curious forms and cavities has given peculiar names to localities, as "Hermit's Grotto," "Caves of the Sand," "Water-washed Caves of the Fairies," all of which exhibit most singular, rounded cavities worn out of the sandstone, sometimes extending into the bluff walls several feet. We may suppose that most of these cavities originally contained a spherical concretion which first determined their present rounded shape, and that the long continued action of the wind and storms has enlarged them to their present dimensions. Perhaps also the trickling of water, or the process of freezing and thawing may have performed a part in disintegrating the particles of sand. Here, too, we find preserved in the rocks the greatest abundance of deciduous leaves of the poplar, ash, elm, maple, etc., and among them some species which are found in the coal formations on the Upper Missouri. Among the fossil plants found is a species of fan-palm, which at the time it grew here, displayed a leaf of enormous dimensions, sometimes having a spread of 10 or 12 feet. These gigantic palms seem to have formed a conspicuous feature among the trees of these ancient forests.

At almost every station, from Bitter Creek to Rock Springs, coal mines are opened, and an abundant supply for railroad purposes can be easily obtained. At one locality, near Point of Rocks, five beds were opened in the same bluff, within a vertical height of 80 feet. These beds are respectively five, one, four, three, and six and a half feet in thickness. Near the summit of the hill, just over the coal, is a seam of oyster shells six inches in thickness. The oyster is of an extinct and undescribed species, about the size of our common edible one.

There are also in this range of hills extensive beds of hard tabular layers of rock, which would make excellent flagging stones. On the surface are fine illustrations of wave and ripple markings, and at one locality impressions which appear like the tracks of a mule on the soft bottom ground. There are others that might be attributed to a huge bird, and others to some four-toed pachyderm. Scattered all through the coal strata are seams and concretionary masses of brown iron ore, sometimes local and sometimes persistent over extended areas; it occurs mostly in a nodular form, and if the coal proves to possess sufficient heating power to smelt it, the ore must become eventually of immense economic value. There are also numerous chalybeate and sulphur springs in the vicinity.

Although the country from Rawlins Springs to Green River presents to the eye the aspect of desolation with very little vegetation, the surface covered with alkaline effloresence, and the water so alkaline and bitter as to be offensive to the taste and unpleasant in its effects, yet to the geologist it is one of the most fruitful of regions. If I were to attempt to work out the geology in detail, it would require volumes instead of a few pages; our knowledge of it is limited as yet, and the area is so large that we must wait years before it will become fully known. In the meantime we have the evidence that a rich reward awaits the persevering explorer.

How many thousands of human beings have toiled their slow and painful way across these dry and dusty plains! A few years ago, the road was lined with graves and the dried up bodies of cattle and horses. But now the scene is entirely changed. Stansbury, in his excellent report, says of this country: "The artemesia constitutes nearly the whole growth, and what little grass had come up has been completely eaten off by the 100,000 animals that have passed before us. Thirty-one head of dead cattle were passed on the roadside to-day, and on the bank of a small drain, where the effloresence of alkaline matter was abundant and rendered the water nauseously offensive, nine oxen lay dead in one heap. They had been poisoned doubtless by the water."

But we must hasten on our journey westward to Green River where objects of still deeper interest await our attention. The scenery along this river is curious and unique, differing from any other which we have seen from Omaha to this point, and we should see nothing resembling it were we to travel to San Francisco. The rugged character of the surface increases as we proceed down the valley until the river unites with the Colorado, and then come those wonderful cañons which have given such wide celebrity to the latter.

Photograph IX. illustrates a peculiar phase of the surface near the junction of Bitter Creek with Green River. The formations are composed of thin layers of fine sand, clay and sandstone or chalky limestone, readily decomposing on the surface, so that the water wears an almost unlimited series of furrows with considerable uniformity. Sometimes on the summits of the hills or ridges harder portions are left, which wear into castellated forms. This peculiar appearance of the surface is not uncommon all over the West where the Cretaceous and Tertiary formations prevail, especially where they are composed of rather soft clays and sands.

The black plastic clays of the Upper Missouri are subject to this style of weathering as well as much of the country usually termed the "Bad Lands."

This appearance of the surface carries with it also the aspect of desolation, with little vegetation but the wild sage-bush, chenopodiaceous shrubs and other plants which love the alkaline soils. Little depressions occur now and then in which the waters will accumulate in wet weather, but in the dry season the water evaporates and the surface is left with a thick incrustation of salts of soda, magnesia, etc.

I have called the formations along Green River, the "Green River Shales," from the fact that the sediments are arranged in regular layers, mostly thin, like shales, varying, however, from the thickness of a knife-blade to several feet. This laminated character, with the slight variations in color, gives to the hills the peculiar banded appearance as shown in photographs XI. and XII. of "Citadel Rock" and "Castle Rock."

Photograph X. illustrates a cut along the railroad through thin layers of a sort of cream-colored chalky limestone. Some of the layers are of a dark brown color, and so saturated with petroleum as to burn with a good deal of freedom. This cut is usually called the "Burning Rock Cut," from the fact that during the progress of the work, the men built a fire by the side of the wall and the rocks ignited, burning for some days, illuminating the labors of the workmen by night and filling the valley with a dense smoke by day. In the distance may be seen the banks of Green River formed of similar rocks, which are made up for the most part of silica, lime, and some alumina, excellent material for the preservation of organic remains. Besides, all the rocks are more or less impregnated with the oily substance, which no doubt, originated from the vast quantities of animals which existed once in this lake, the remains of which are found in the greatest abundance everywhere. One of these excavations along the railroad bears the name of the "Petrified-fish Cut," on account of the thousands of beautiful and perfect impressions of fishes which are shown on the surface of the thin slabs, sometimes a dozen or two on an area of a square foot. Impressions of insects and water plants are also found as well as of a remarkable specimen of a feather of a bird, which Professor Marsh regards as a unique specimen, forming a most interesting addition to the bird remains of North America. "It is the distal portion of a large feather with the shaft and vane in such excellent preser-

vation, that it may perhaps indicate approximately the nature of the bird to which it belonged."

My collection of fossil fishes from these shales was very large, and my success was mostly due to the kind aid of Mr. A. W. Hilliard, a gentleman of intelligence, who superintended the excavation on the line of the railroad, and preserved from time to time such specimens of value as came in his way. Professor E. D. Cope, the distinguished comparative anatomist of Philadelphia, has kindly prepared the following account of the petrified-fish remains, which were submitted to him for examination, especially for this work:

"The fishes placed in my hands by you for determination, consist of four species, viz.: one *Acanthopterygian*, *Asineops Squamifron*, Cope, and three *Malacopterygians*, *Clupea humilis*, Leidy, *Clupea pusilla*, Cope, and *Cyprinodon levatus*, Cope. Those named by the writer were not previously known, and the Asineops represents also a genus not before brought to the notice of scientific men. In ordinary language, the last mentioned fish is a perch, but in no degree similar to the white and yellow perch brought to our markets. The nearest resemblance in general structure is to be found in the black bass of the Ohio and Tennessee Rivers, but a closer similarity in form exists in the red-eye, or goggle-eyed perch of western and southern rivers, the Ambloplites of naturalists. Zoologically, it is not very nearly related to either, for it combines with some of their characters, others now only existing in marine fishes, of other families. It is an aberrant form of the family of Chætodons, which embraces marine fishes only, and which chiefly abounds at the present time in the Indian and Pacific Oceans. But the form and proportions of its fins and scales remind one very much of the swamp and tide-water sun perch of New Jersey, *Acantharchus pomotis*, Baird, (*Bryttus* Lp., etc.,) and suggest a similarity of habit. The teeth are fine and the dentition brush-like, as in many fresh water and marine perch, and its food was probably much like theirs. As far as zoological evidence goes, there is nothing to indicate whether this species belonged to fresh or salt water; its unarmed character constitutes a peculiarity much more prevalent among fresh water than marine fishes, while its zoological affinities so far as known are altogether with marine forms. In size this fish exceeded the red-eye, and was less than the black bass, averaging about that of the yellow perch.

"The Clupeas are herrings of small species, considerably smaller than the herring of our coasts.

"One of the blocks contains the remains of two small shoals of the fry, probably of Clupea humilis, which were caught suddenly by a slide or fall of calcareous mud, and entombed for the observation of future students. They must have been taken unawares, since they lie with their heads all in one direction as they swam in close bodies. One or two may have had a moment's warning of the catastrophe, as they have turned a little aside, but they are the exceptions. The fry are from one-half to three-quarters of an inch long and upwards.

"True herring, or those with teeth, are chiefly marine, but they run into fresh waters and deposit their spawn in the spring of the year, and then return to salt waters. The young run down to the sea in autumn and remain there till old enough to spawn. The size of the fry of the Rocky Mountain herring indicates that they had not long left the spawning ground, while the abundance of adults suggests they were not far from salt water, their native element. To believe then, that the locality from which the specimens were taken was neither far from fresh, nor far from salt waters, is reasonable; and this points to a tide, or brackish inlet or river. Lastly, the species of Cyprinodon inhabit also tide and brackish waters. Most of the species of the family, as well of the genus, are inhabitants of fresh water; but they generally, especially the Cyprinodons proper, prefer still and muddy localities, and often occur in water really salt. This habitat distinguishes them especially from Cyprinidae (Minnows and Suckers) and Pike.

"The materials which compose the shales indicate quiet water, and not such as is usually selected by herring for spawning in; while the abundance of adult Clupeas indicates the proximity of salt water.

"This is far from a satisfactory demonstration of the nature of the water which deposited this mass of shales, but is the best that can be obtained with such a meagre representation of species.

"As to geological age, the indications are rather more satisfactory. The genus Clupea ranges from the upper Eocene upwards, being abundant in the slates of Lebanon and Monta Bolca, while Cyprinodon has been found in neither, but first appears in the Middle or Lower Miocene in Europe. The Asineops resemble very closely, and I believe essentially, the Pygeaus of Agassiz, of Eocene age, from Monta Bolca. The peculiarities presented by the genus found by Dr. Hayden, are of such small significance as to lead me to doubt the beds in question being of later than

Eocene age; though the evidence rests chiefly on this single, new and peculiar genus.

"The position of these fishes, 7,000 feet above the level of the sea, furnishes another illustration of the extent of elevations of regions once connected with the ocean, and the comparatively late period of Geologic time at which, in this case, this elevation took place."

Professor Samuel H. Scudder, Secretary of the Boston Society of Natural History, has very kindly furnished me the following notes on the fossil insects that have been found among the fishes at the same locality:

"The fossil insects found by Dr. Hayden in the Tertiary shales of Green River belong to three species: one being an ant, the others flies. The ant is rather poorly preserved, and must be examined with great care before its precise character can be determined.

"The large fly, of which we can distinguish almost the whole of the body, though but little of the wings, evidently belonged to some species of *Syrphidae;* it is nearly three-fourths of an inch in length, and seems to have had a bright colored abdomen, banded with black. In their perfect state, all of this family are fond of flowers, but the typical species are particularly interesting from the peculiar habits of the larvæ; these are footless grubs which feed on plant lice, piercing them one by one and sucking out their juices; it is more likely, however, that our species belonged to one of the genera whose larvæ live in the water on and about decaying vegetable substances. Larvæ, which from their size and general form might well produce such a fly as this, were found abundantly by Professor Denton, and they evidently inhabited the water.

"The other fly, judging from the neuration of the wings, which is pretty well preserved, seems to belong to the great family of *Muscidæ*, of which the common house fly is an example; it may probably be referred to a section, in which the alulets are nearly or quite wanting, and whose larvæ ordinarily feed upon dead animal matter or upon decomposing plants.

"Belonging to the same group and perhaps nearly allied, are species of *Ephydra*, which live in salt marshes and frequent saltpans to such an extent as to be very troublesome; they have been discovered in the saline waters of some Nevadan lakes, and Professor Denton states that dipterous larvæ, probably of a similar kind, are found in great numbers in lakes impregnated with petroleum. It is probable that the shales, in which these remains occur, were deposited in such a lake."

About a mile west of the "Petrified-fish Bed," is a cut along the railroad which passes through a moderate thickness of bnff, chalky limestones, filled with impressions of leaves of deciduous trees. These rocks hold a position about 100 feet above the petroleum shales which contain the fish remains, and therefore, the date of their existence may be regarded as subsequent, though belonging to the same basin. Professor J. S. Newberry, our best authority on the fossil vegetation of America, has given these plants a hasty examination, and communicated the following interesting notes in the form of a letter:

"I have examined the plants from the Green River beds with as much care as the limited time at my command would permit, and am surprised in not finding among them a single species contained in any of your other great collections at the far West. They, thus far, afford no certain criteria for collating the Green River Tertiaries with those of other localities where you have studied them. The plants from the rocks enclosing the coal at Marshall's mine are more significant, as they include species (*Platanus Haydeni* which is certainly different from *Platanus Aceroides*) such as were found by you at Carbon Station and at the mouth of the Yellow Stone. Every collection of fossil plants received from the Tertiary of the West brings to light many new species, and the great diversity which they exhibit proves either a number of plant-bearing horizons, or great localization of the species in the Tertiary flora.

"Among your Green River plants are only some half dozen species, so well preserved as to be capable of satisfactory identification or comparison, but they form a very interesting group. Among them I find two palms, both quite unlike anything before found on this continent. One is a new *Phenicites*, resembling Heer's *Manicaria formosa*. The other but an imperfect fragment, yet altogether new and strange to me. The most abundant species contained in the collection is a *Magnolia*, allied to *M. tenuinervis*, Lesqx, but more elongate and acute, also an oak resembling *Quercus Saffordi* of Lesqx. There is another oak in the collection, a laurel (probably), and fragments of two ferns, too imperfect for determination. On the whole, these plants resemble most those described by Lesqueruex from Mississippi, and I am inclined to suspect are of the same age. This would make the Green River beds older than you have thought them, and I should want more material before venturing anything more than a suggestion to that effect. I trust you

will be able to make other collections from these plant-beds during the present season.

"The specimens contained in the buff, marly limestones of the Green River series are generally not well preserved, and yet, I think, careful search at the locality, where these plants sent me were obtained, would result in the discovery of some fine things. I would especially urge a search for fruits.

"The aspect of the small group of plants now before me from Green River is more tropical than any you have brought from the West, and as we have reason to believe that our Eocene climate was warmer than the Miocene, and that from the Eocene epoch to the Glacial period a progression of temperature took place, the Green River beds would seem to me to prove earlier than late Miocene."

Geologists have as yet explored this interesting region only in the most superficial way, and we have caught but a glimpse of the wonderful treasures which will some time be brought to light. The strata are nearly horizontal, and the rivers have cut such deep channels in them that they can be studied with comparative ease. Professor Denton, who made an exploration of the country about 100 miles south of the railroad, has given a graphic account of his discoveries, which shows very clearly the geographical extension of this formation. Near the junction of White and Green Rivers, partly in Colorado and partly in Utah, he describes an immense Tertiary deposit, composed of a series of petroleum shales, 1,000 feet in thickness, varying in color from that of cream to the blackness of cannel coal. The shales abound in the impressions of leaves and of various species of insects. Mr. Samuel H. Scudder, of Boston, published in the "American Naturalist" for February, 1868, a most interesting account of the insects collected by Professor Denton. He says:

"The masses of rock were crowded with remains of insects and leaves of deciduous trees. Between 60 and 70 species of insects were brought home, representing nearly all the different orders; about two-thirds of the species were flies, some of them the perfect insect, others the maggot-like larvæ, but in no instance did the image and larvæ of the same insect occur. The greater part of the beetles were quite small, there were three or four kinds of *Homoptera* (allied to the treehoppers), ants of two different genera, and a poorly preserved moth. Perhaps a minute *Thrips*, belonging to a group which has never been found fossil in any part of the world, is of the greatest interest.

"At the present day these tiny and almost microscopic insects live among the petals of flowers, and one species is supposed by some entomologists to be injurious to the wheat, others believe that they congregate in the wheat as well as in the flowers, in the hope of finding food in the still smaller and more helpless insects which are found there. It is astonishing that an insect so delicate and insignificant in size can be so perfectly preserved in these stones; in the best specimens the body is crushed and displaced, yet the wings remain uninjured, and every hair of their broad but microscopic fringe can be counted."

Professor Denton also discovered in this region a deposit of petroleum coal, which appears identical with and would yield as much oil as the Albertite coal of New Brunswick. Another bed resembling Cannelite was noticed 10 to 20 feet in thickness, which Professor Denton believes would produce 50 or 60 gallons of oil to the ton. If so, a single bed here would yield twenty million barrels of oil, or a thousand times as much as America has produced since petroleum was discovered in Pennsylvania. It is clear that these shales with the fossil insects, leaves and petroleum are only a southern extension of the beds which we have so fine an opportunity to study around the Green River Station.

From Bryan we pass over a peculiar region, differing again in its surface features from any previously seen on our route. Far distant to the southward the singular dome-like appearance of what we have usually styled the "Bad Lands" is visible, their brown and indurated sands and clays having weathered into remarkable forms. Photograph XIII. is a fine view of a noted landmark along the old stage road, which has received the name of "Church Buttes," from its supposed resemblance to a church. To this formation I have given the name of the "Bridger Group," and I am convinced that this region was occupied by a vast fresh water lake, about the same time that the one on White River existed. From the indications derived from the fossil remains already discovered, this group of beds is destined to yield a fauna second only to that of the "Bad Lands" of Dakota. So far as yet known all the remains appear to be of Middle Tertiary age. Among these fossils those of turtles are especially numerous, a multitude of fragments together with several forms nearly entire, have been collected and sent to Professor Leidy, of Philadelphia, for examination. The specimens have been referred to three extinct species; the greater number pertain to a fresh water turtle which

has been named *Trionyx guttatus*. The genus to which it belongs is found at the present time living in the rivers of America, Asia and Africa. It is represented in our country by the *Trionyx ferox* or great soft-shelled turtle of the Mississippi and its tributaries. The animal is noted for its voracity and feeds on fishes, snakes and young alligators. Its ancestor of the Bridger Tertiary period no doubt was equally predaceous in its habits.

Another turtle, of which a nearly complete specimen was discovered, was more like our marsh terrapins in character. It, however, belongs to an extinct genus and species to which Professor Leidy has given the name of *Baptemys Wyomingensis*, from the habit which it no doubt possessed in common with most of its tribe, of at least taking an occasional plunge in some convenient bathing place. Some of the nearest living relatives to this turtle are now found in Central America, the so-called *Dermatemys* and *Staurotypus* of Vera Cruz and Tobasco. The third species of turtle indicated by fragments, Professor Leidy has referred to a terrapin which he has named *Emys Stevensonensis*, in honor of James Stevenson, the companion and able assistant of the author during his geological explorations of the interior of our continent.

From other fossil remains from the Bridger group of rocks, Professor Leidy reports the former existence of an animal presenting an affinity to the hyæna and panther. It was larger than our species of the latter, and was evidently a predaceous animal of great strength and ferocity. It has been named *Patriofelis ulta*, which signifies the ancestral cat that hath revenged itself. The remains of a small animal discovered by Mr. J. A. Carter, of Fort Bridger, and sent to Professor Leidy, were referred by him to an insect-eater related to the European hedgehog, to which he has given the name of *Omomys Carteri*, in honor of its discoverer.

It will thus be seen that all the animals indicated by the fossils from the Bridger bed, comprising three different turtles, a carnivorous and an insectivorous mammal, are of species and genera previously unknown to science. They, therefore, indicate an especial fauna, accompanied by a peculiar flora, of which thus far we have seen but a trace. Farther researches will most probably give to us an interesting history of the lost race of animals, of the former existence of which we now have an intimation.

There are also beds of limestone, composed entirely of a small species of *Cypris* which gives to the rock a beautiful oölitic structure. Of fresh

water mussels *Unios*, *Melanias*, *Viviparas*, *Planorbis*, several species are found at different localities. Sometimes the *Melanias* and *Unios* are found on a slab of limestone in great numbers, filled with chalcedony. All the evidence that we can secure, points to the conclusion, that all the sediments of the Bridger group were deposited in the bottom of a purely fresh water lake, with no access to salt or even brackish water from any point. In regard to the extent of this great and most interesting lake-basin very little is known. All the explorations have been, hitherto, of a hurried and superficial character. We believe that the Uintah Mountains form the southern shore, and that it extends down to the valley of Green River, at least to the entrance of White River, and probably farther. Professor Denton's graphic description satisfies us that the formations are identical with those around Church Buttes:

"Looking from the summit of a high ridge on the east, a tract of country containing 500 or 600 square miles is distinctly visible. Over the whole surface is rock, bare rock cut into ravines, cañons, gorges and valleys, in magnificent relief, terrace upon terrace, pyramid beyond pyramid, rising to mountain heights; amphitheatres that would hold a million spectators, walls, pillars, towers, castles everywhere. It looks like some ruined city of the Gods, blasted, bare, desolate, but grand, 'beyond a mortal's telling.' Originally an elevated country, composed of a number of soft beds of sandstone of varying thickness and softness, underlaid by immense beds of shale, it has been worn down and cut out by rills, creeks and streams, leaving this strange, weird country to be the wonder of all generations."

But we must not leave this singularly interesting region without a word in regard to the "Moss Agates" which cover the country from Green River to Fort Bridger in the greatest profusion. The ground in many places seems to be literally paved with nicely rounded pebbles and small boulders, mostly of agate flint, the largest not more than four or five inches in diameter; there is a belt of about 10 miles in width, from east to west, including Church Buttes, and extending an unknown distance from north to south over which these gems are found in the greatest abundance and variety; I am inclined to think they originate in this modern Tertiary formation. About six miles west of Carter's Station a cut in the railroad reveals a bed of tough, dark gray plastic clays, and at the top a layer of flinty concretions filled with small seams of

chalcedony. In the "Bad Lands" of White River are abundant seams of fine chalcedony, which only need the oxide of iron or manganese to make the choicest of moss agate. I am inclined to believe that these agates originate in irregular seams in the Tertiary beds somewhere south of Church Buttes. The origin of all the drift material which strikes the eye everywhere, I regard as local and that it was probably transported from the direction of the Uintah Mountains.

Some of these gems are very beautiful, and the sprangles or dentritic delineations are wonderfully like the stems of moss, and it is quite difficult for most travelers to believe that they are not actually plants imprisoned in the flinty mass. Most of the agates are of little value, but occasionally one is found of great beauty that will sell for $50 or $75. They are also found in the Middle and South Parks to some extent; those in the Middle Park being regarded as by far the best. Beautiful specimens of opal, semi-opal, or opaline occur, and when found are especially attractive. A variety of opal of a milky white color and very transparent, was found in a lode of gold-bearing quartz, near Idaho, Colorado, and was much sought after for a time.

CHAPTER VI.

FROM BEAR RIVER TO SALT LAKE VALLEY.

FOR more than 200 miles we have passed through one of the most desolate regions in the West. Even the most enthusiastic and cheerful of our companions in travel will not hesitate to pronounce it a desert. But now, as we proceed westward from Fort Bridger, we note at once the favorable change that takes place in the aspect of the country and of the vegetation. Broad plains and sloping hills, covered thickly with grass, with an almost entire absence of the wild sage are now the rule. Patches of the quaking asp appear here and there, and along the streams are fringes of the cotton wood.

Bear River is, in some respects, one of the most interesting streams in Utah, and if it were carefully described from source to mouth, it would add a very interesting and instructive chapter to this volume. It takes its rise in the Uintah range of mountains, about 60 miles south of the line of the road, flows northward 200 miles or more, and makes an abrupt bend around to the south for a long distance, and flows into Great Salt Lake. It gathers its waters from the mountains in many tributaries, all of which are filled with fine trout. The scenery is wild and picturesque in the extreme. Photograph I., which forms the frontispiece of this volume, was taken near the source of this stream, and represents one of the numerous beautiful crystal lakes which are set like gems in these mountain valleys. I have not yet visited this portion of the range, and therefore, will not attempt to describe the country in detail; but I was informed by Mr. Russell, that the rocks which compose the mountains in the distance, as well as those in the foreground, are quartzites. There is

an abundance of the finest timber in these mountains, such as spruce, pine, balsam fir, etc.

Photograph XIV. is another view of the lake, with the mountains shown more distinctly and clearly. Hundreds of such views might be obtained in this region, but those here given will reveal the beautiful symmetry of the outlines of the mountains with the forests of pines at the base. Very little accurate knowledge of the geology of this interesting region has yet been given to the world. Mr. Clarence King, United States Geologist for the 40th north parallel, under the direction of the War Department, has made a careful examination of this district under favorable auspices, and the result of his labors will be of the highest interest.

There can hardly be found on this continent a more delightful region to explore at the present time than that included within the area occupied by the different ranges of mountains surrounding Salt Lake Valley, more especially the Wasatch and Uintah. Hundreds of beautiful streams have cut deep, gorge-like channels down the sides of these mountains, and as they come out into the plains they expand into broad, grassy, fertile valleys, contrasting most favorably with the vast desert region eastward. A description of one of these beautiful streams would apply to a certain extent to all, for all of them form the most rugged and picturesque scenery that can be well conceived.

But our route of travel for the present is along the valley of Bear River. We have passed the western rim of the Bridger Basin, and near Quaking Asp Summit enter upon the borders of the great valley of Salt Lake. The geological character of the country is entirely changed; instead of the brown and light gray sands and clays of the Bridger group, we have the curiously variegated beds of the Wasatch group, which present almost every variety of shade of color from white and yellow to a deep brick-red, the red and purple tints so predominating that they give a singularly curious aspect to the scenery.

The beds of the Bridger Basin near Church Buttes and Fort Bridger incline to the east, but are nearly horizontal and seem to jut up against the mountain sides with very little inclination. The style in which they have weathered or suffered erosion, their position in elevation to the older formations, and the general appearance of the surface, suggest some connection in time with the White River group on the eastern slope, but the sediments are more arenaceous. I am inclined to the opinion, that

while they may be regarded as independent lake-basins, they existed at the same time, during the later portion of the Tertiary period.

The western rim of this recent fresh-water basin is well defined at Quaking Asp Ridge; here the examples of erosion are displayed on a tremendous scale, and the rounded, water-worn boulders almost pave the ground. We will observe that the west sides of the hills are quite abrupt and covered with worn rocks, while the eastern sides slope gently down in long ridges, showing the direction from which the forces have acted as well as their local character, also that they originated somewhere in the direction of the mountain ranges, and by scooping out the valleys strewed the surface of the plains with rocks. The cuts of the railroad, which are numerous, reveal with great distinctness the beds of brick-red and purplish clays and sands.

From Aspen Station to Wasatch, at the head of Echo Cañon, these red beds are not so conspicuous along the immediate line of the road, but in the distance they can be seen on either side. In a few localities the black, sombre clays of the Cretaceous, overlaid by the coal beds are seen. But the traveler will be most attracted by the numerous indications everywhere of evident convulsions in past geological times, by which the rocks have been thrown into every conceivable position. Near Bear River City the coal formations hold a nearly vertical position. There is here an outcropping of coal eight to ten feet in thickness. A little west of the city is a cut 200 or 300 feet long, which shows the fluxes of the curiously banded strata in a most remarkable manner, and no where else have I ever seen a similar illustration. There are here exposed nearly 200 layers, of almost every variety of texture from sandstone, clay and fine sands to earthy lignite, and many of these seams are so crowded with fossil shells in a fine state of preservation, that they may be gathered by the bushel. The sides of the cut are so peculiarly banded, that they look like the stripes of a zebra. At the east end, these layers are nearly vertical, but at the west they seem to have been, as it were, lapped or bent down so as to form an abrupt curve, as if there had been tremendous pressure from above. A little farther westward, we see a ridge of the red beds and conglomerates inclining gently to the west and resting unconformably upon the upturned edges of the rocks in the cut.

But along no other portion of our route have I ever seen so rich a locality for fossil shells of a few species. In the cut, on the hills on either

side of Bear River, the ground is literally paved with them, and the collector may gather them as he would the sands on the sea shore. They are mostly land and fresh water species, many of them as yet undescribed. Mr. F. B. Meek has made out a partial list, and he finds several species of fresh water mussels, *Unios* and some interesting estuary forms which indicate brackish water, or partial access to the ocean in those times. The conclusion, however, is that all these rocks are of Tertiary age.

There is here another interesting feature, the oil springs of Bear River, which have made this country famous for many years. More than 20,000 acres of oil lands, in claims of 160 acres each, have already been surveyed and located by different parties. Companies have been formed and shafts sunk, preparatory to an extensive business the coming season. The external appearances are certainly very favorable. A considerable quantity of the crude oil flows from these springs constantly, and accumulates in small depressions or in the channels of the stream. When the oil first issues from the ground it has a bright green color, but it soon changes on exposure to a dark brown and has a slightly aromatic taste and smell. Similar springs occur in the valleys of Wind River, of the Sweet Water, and also of the Arkansas River, near Cañon City, Colorado. At the latter locality about 4,000 gallons of refined oil have been made per year, for the past three years. It is readily purchased by the inhabitants of the country, who regard it in all respects as equal to our Eastern oils for domestic uses. I will not here attempt to explain the origin of these Western oils, but I suppose that they are derived from a similar source with those of the East. Geologists differ as to whether the oil is derived from vegetable or animal remains, but it is certain that it is not confined to any particular formation or geological period. In the valley of the Arkansas, the springs are located in rocks of Cretaceous age, while in Bear River valley the oil flows up through Tertiary strata, though in some instances it evidently rises from beds as old at least as the Cretaceous.

About 20 miles west of Fort Bridger, on the Overland Stage road, there is a fine soda spring, yielding the most delicious water; it does not differ materially from that of the soda springs in the valley of the Fontaine qui Bouille, at the eastern base of Pike's Peak.

Bear River Valley has been noted for many years for its numerous mineral springs. Indeed, all Utah Territory is celebrated for them, but

in times past the numerous springs in this valley have attracted most attention.

About 10 miles below the station, on the right side of Bear River, is Medicine Bow Butte, which looms up conspicuously above the surrounding country, 800 to 1,000 feet above the bed of the stream. It is undoubtedly composed, for the most part, of strata belonging to the coal series, which I am disposed to regard as of Tertiary age. It is well grassed over, and is covered here and there with dense groups of quaking asp, poplar, etc.

Passing on the stage road westward from Bear Creek Station, over beds nearly horizontal or inclining at a small angle, we suddenly come to an upthrust of rocks, called "The Needles," which the traveler coming from the East for the first time will regard with astonishment. Deep underneath an extensive covering of more recent deposits, there seems to be an immense bed of coarse conglomerates, and at this locality, by upheaval, these conglomerates have been thrust up through the softer overlying beds in a nearly vertical position several hundred feet above the road, and have been weathered by atmospheric influences into a number of sharp conical peaks, which have given to this landmark the name of "The Needles." It is made up of all kinds of worn boulders and pebbles, like those we see forming the bed of any of our mountain streams, varying in size from that of a pea to a foot in diameter. These rocks are held together somewhat loosely by a kind of silicious grit. Some of the worn masses are themselves an aggregate of worn pebbles, proving that a portion of the materials were derived from still older conglomerates. Sometimes there is a thin local seam of coarse sand containing only a few pebbles, but the greater part of the entire mass, 500 to 1,000 feet thick, is a coarse conglomerate. It is situated near the Yellow Creek Station, and the ridge of upheaval extends down from the Uintah Range. As we go westward, examples of these massive conglomerates will not surprise us, and in Echo Cañon we shall find them 3,000 to 5,000 feet in thickness; I believe all are of modern Tertiary age.

From the hills about a mile west of Yellow Creek Station we have some of the finest and most extensive views of the country. With a good field glass we can see objects with considerable distinctness on a clear day for a distance of 50 to 100 miles in every direction, over a most rugged surface with high ridges and deep gorges, the strata showing red,

yellow, gray and, indeed, every variety of color. Far to the south we can see the Uintah Mountains, their summits covered with snow the greater portion of the year, forming a most beautiful and symmetrical background to our scene. To the southwest, dimly seen, is the Wasatch Range, which separates us from one of the objects of our visit to this country, the Great Salt Lake. North of the road the Goose Creek Mountains are faintly visible, but still loom up with sufficient magnitude to invite our attention.

At Evanston we leave Bear River Valley and proceed on our way westward, while the river flows far northward into Idaho to Port Neuf Gap, near latitude 42½° N., then it suddenly and almost abruptly fluxes about and flows southward until it empties into Bear River Bay, a portion of Great Salt Lake.

We may stop at Evanston and study the interesting coal mines with profit. With one exception this is the last point along the line of the road before reaching the Pacific Coast, where we will have an opportunity to examine coal mines possessed of any economic value. The coal is located about three miles from this place on the east bluff of Bear River Valley, and is exposed over but a small area. It seems to have been revealed by the inclination of the coal strata to the east, and the entrances have been made at the base of the bluffs but a few feet above the bed of the valley. A branch railroad has been constructed to these mines, and there is now no limit to the amount of fuel they can furnish.

The mines have been opened with more system and at greater expense, and I regard them as more valuable, and the coal of a better quality, than any I have ever seen west of the Mississippi. Five entrances have been made, each one showing a vertical front to the coal bed, varying from 20 to 26 feet. The dip is about northeast, and varies from 12° to 19°. For a distance of about a mile along this abrupt rocky bluff the coal seems to be exhibited on the grand scale above described, but proceeding either way from that point it disappears or becomes almost inaccessible. About 100 feet above the coal bed there is a layer of calcareous sandstone filled with leaves, apparently belonging to extinct species of the genera *Magnolia*, *Telia*, *Salix*, *Ulmus*, *Platanus*, though very much resembling in form those of our existing forest trees. These leaves indicate that these rocks are of Tertiary age.

The summits of the hills are capped with a thick bed of conglomerate,

probably of the same age with that which forms "The Needles" near Yellow Creek, and also that shown so grandly in Echo and Weber Valleys. At this point there is a broad expansion of Bear River Valley, which makes it a most attractive site for a city. There are here thousands of acres of fertile land that could be easily irrigated, and even now they form a vast meadow, covered during the summer and autumn with a luxuriant crop of grass.

From Evanston we might branch off in any direction and visit places of great interest, of which but little is known as yet. Not far northward we might take a glance at Bear Lake Valley, which is destined to be a point of great interest not only to tourists, from the grandeur of the scenery and the beauty of the lake from which it takes its name, but also to settlers on account of the fertility of its soil. This lake is an expansion of a branch of Bear River, and is about 15 miles long and four or five in width, and well stocked with trout. About 30 miles to the north are the far famed soda springs of Idaho, which will repay the time spent in visiting them.

Taking the cars again at Evanston, we shall soon find ourselves at the divide between Bear River and Echo Cañon, at an elevation of about 7,000 feet above tide water. The country we have passed over presents nothing new or striking; the same reddish clays and sands which we have seen before seem to have been worn down into a fine rolling surface, which is covered with a good growth of grass, giving the whole scene a cheerful aspect. Game, as antelope, elk, deer, bear, etc., was formerly abundant all over this region, and the experienced, wary hunter might discover some even at this time, but all along the line of the railroad game of all kinds is fast disappearing.

The tunnel at the head of Echo Cañon is cut through the reddish and purplish indurated sands and clays of what I have called the Wasatch group of Miocene Tertiary age; it is 770 feet in length, and is the longest tunnel on the Union Pacific Road. After passing through it the trains move slowly over the piers of trestle work, which creak and tremble beneath their load. One section is 230 feet long and 30 feet high, the other 450 feet in length and 75 feet high. We then enter one of the narrow, grassy valleys which leads soon into Echo Cañon, and then we sweep rapidly down between lofty conglomerate walls on either side, which have been weathered into the most fantastic forms.

Indeed, this entire valley is, for the most part, one of erosion. The water in past geological times has carved out of the massive conglomerates its deep channel, and on either side the rocks rise wall-like 500 to 1,000 feet. Some portion of the lower part of the valley passes through a monoclinal rift, that is, the beds incline to the northwest, so that on our right as we descend we see the projecting edges. All these beds seem to have a greater or less dip to the northwest, apparently from the Uintah Range.

At the head of Echo Cañon the first objects that attract our attention are the massive reddish sandstones on our right, 500 to 800 feet high, which have weathered into curiously castellated forms, and to which the general name of "Castle Rock" is given. As we pass down through some of the wildest scenery in the world, our eye will be constantly arrested by some unique shape into which these variegated sandstones and conglomerates have been worn by time; "Witches' Rock," "Eagle Rock," "Hanging Rock," "Conglomerate Peaks," "Sentinel Rock," "Monument Rock," all greet us in turn as important landmarks. Our illustrations serve well to show the variety of this wonderful scenery, and as "Rock Studies" they are unsurpassed. To the intelligent eye they speak for themselves better than pages of description.

The Conglomerate Peaks of Echo, as represented in photograph XV., present a near view of these conglomerates, so that even the depressions in the smoothly worn surfaces of the boulders can be distinctly seen. A little side stream has worn a deep gorge and scattered vast piles of debris below. The different sizes of the pebbles are also well shown; its walls are about 500 feet high.

Photograph XVI. is a view of one of the most remarkable landmarks in this valley. "Monument Rock" is a regular obelisk of conglomerate; standing at the junction of the Echo with the Weber Valley, nearly 1,000 miles west of Omaha. It is about 250 feet high, and forms another illustration of the peculiar style of weathering by which rocks assume the appearance of animals. This column has been very aptly called the "Dog's Head," to which it will be seen at a glance that the summit bears a resemblance.

The peculiar form of stratification, with the varied texture, sometimes a fine sandstone, then a fine pudding-stone is remarkably well displayed in the picture, and the same variations of structure on a still larger scale may be seen throughout the valley of Echo and portions of Weber Cañon.

The inclination of the strata is also well shown. The base is composed of rather fine sandstone, but these sandy layers are not permanent over areas, but often within a distance of a few feet run into coarse large conglomerate.

Photograph XVII. presents to us one of the most striking views in this region. It is called "Hanging Rock," and is a mass of coarse conglomerate, overhanging its base about 50 feet. It overlooks Echo City and the valley of the Weber, through which a beautiful stream of pure mountain water winds its way. On the opposite side of the Weber, the partially rounded grassy foot-hills of the Wasatch Mountains may be distinctly seen. The Weber River also flows a portion of its way through a monoclinal valley, the abrupt, nearly perpendicular sides of the conglomerate bluffs rising up like gigantic walls 800 to 1,000 feet, while on the left, the gently sloping sides of the inner series of ridges are well displayed. The isolated rounded mass, which seems to stand alone and almost ready to tumble into the valley below, is quite firmly seated on its bed of sandstone, and the corresponding portions may be seen forming the base of the hanging rocks, just back of the man seated on the ground, as represented in the photograph. I call attention to these strata of fine sandstone as a matter of geological interest. High above the bed of the Weber, 800 feet or more, rises the conglomerate bluff with nearly perpendicular sides, and from its summit one can survey the country for a long distance in every direction, and enjoy the multitude of most attractive views offered.

As we descend Echo Valley, we emerge from the cañon around "Pulpit Rock," and shoot our way with wonderful rapidity down the picturesque valley of the Weber. We shall observe that as we descend the Echo Cañon, the more rugged picturesque scenery is exhibited on our right hand, and as we descend the Weber, the same lofty perpendicular walls, weathered here and there into all sorts of fantastic forms, continue to the "Narrows," where the Weber River makes a bend to the left and the conglomerates disappear. This formation, which in some respects is the most remarkable one which I have ever seen in the West, must have a thickness of 3,000 to 5,000 feet. The conglomerate portion above must be 1,500 to 2,000 feet in thickness. I have included in this group all the variegated beds which we have observed west of Carter's Station, and we have noticed especially that some shade of red has prevailed in the clays

and sands, as well as in the conglomerates of this group. Some of the sandstones in the upper portion of Echo Cañon are noticeable for their deep yellow hue. I have called this series of beds the Wasatch group. How great is the area occupied by these formations I have never ascertained. I regard them, however, as forming the materials deposited in one of the great lake-basins of the Middle Tertiary period, the history of which, if we knew, it would be too long and tedious for this volume. But if fine sands require moving waters for their deposition, what kind of aqueous forces must have been employed to transport these boulders into this lake-basin? From whence were they derived, and what were the powers that wrenched them from their parent beds, smoothed them into their present rounded form, and then aggregated and cemented them together into such huge masses as we find here? We have presented to the reader three fine views of these remarkable rocks as studies representing this group.

We could not spend a few days with greater profit and pleasure than to make Echo City our headquarters and wander among the wild and rugged scenes of this romantic region. If we were to ascend the Weber River to its source in the Wasatch Mountains, we should gain a knowledge of only one of the hundreds of beautiful valleys which everywhere characterize the mountain ranges of Utah. The waters of the Weber are gathered from a multitude of little branches, which carve out deep picturesque channels down the mountain sides, and the cold, pure, crystal waters are supplied from perpetual springs and the melting of snows. The valley of the Weber from mouth to source is quite thickly settled with Mormons. In photograph XVIII. the reader can see the little Mormon village of Coalville, about five miles above Echo City, which derives its name from the coal mines that have been opened there. I have selected this view because it represents the most western locality of workable beds of coal along the line of our great trans-continental railway, with which we are acquainted. The last place where we noted the existence of coal along the railroad, was near Evanston Station, and we described its restricted area. We shall observe here also, that the position of the different strata precludes the possibility of the coal beds being exposed over more than four or five miles square. All the coal that has been used at Salt Lake City or in any of the Mormon settlements for years has been obtained from this locality. Large rewards have been offered by President Young

for the discovery of coal in other portions of Utah accessible to Salt Lake City, and we may be assured that every mountain recess has been scrutinized with the greatest care, but all in vain.

The illustration shows the character of the valley, its broad bottoms, its gardens and fields of grain. The soil is very fertile and produces all the roots and cereals in abundance, but the elevation is too great for the production of fruits; indeed, nowhere east or north of the valley of Salt Lake do the settlers succeed in raising them. The conspicuous frame building in the picture is the Mormon meeting-house; the coal mines with the greater portion of the village are situated on the right of the Overland Stage road, so that they do not appear. In the background on the south side of the Weber, we can see the high hills with heavy beds of gray and yellow sandstone projecting from their sides. On the north side, not shown in the picture, are still higher, steeper and more rugged hills or bluffs. Chalk Creek flows into Weber River at the lower end of the town, and from this little branch to Echo City the distance is about four miles in a straight line, and two and a half miles of it are occupied by from eight to twelve ridges of coal strata, which incline at an angle of 10° to 30°, so that at Echo City, on the immediate line of the road, the coal beds of Coalville must be 1,500 to 2,000 feet beneath the surface. As at Evanston and many other localities, it is only by the operation of the eruptive forces that elevated the mountain ranges, bringing up the older rocks to view, that the coal is exposed here at all. The geological age of the coal beds at Coalville is an important question to geologists, and one which still remains to be settled positively. I have supposed that they belonged to the same basin with the Bear River coal beds, which I regarded as of Tertiary age, but the fossils obtained from the high hills, which are shown in one photograph, and which appear to be above the coal, have a Cretaceous aspect, although no species as yet discovered here has proved to be identical with any of the well known Cretaceous forms.

Echo City is 993 miles west of Omaha, 781 miles east of Sacramento, and is 5,707 feet above the sea. Southwest of the station, on the opposite side of the Weber, are a series of ridges which incline from the Wasatch Range, among which are many beautiful valleys with little streams, and here and there a gem of a lake well stocked with trout and other kinds of fish; deer, antelope, elk and mountain sheep are still to be found. The sportsman could here find amusement to his heart's content.

An interesting feature along this valley, and one which we shall allude to again in another place, is its terraces. Near Echo City there is a rather narrow bottom close to the river, then an abrupt ascent of 30 feet, then a level plain or bottom of 200 to 400 yards in width, then a gentle ascent to the rocky bluffs. These terraces are shown in the valleys of all the streams flowing into Salt Lake, and are also undoubtedly connected in their history with those conspicuous all along the base of the mountain ranges, surrounding Salt Lake Valley.

Seven miles below Echo Station the road passes through a remarkable gorge or chasm, called the "Narrows." The Weber River through the greater part of its course flows through a monoclinal rift, that is, between two ridges of upheaval, where the upturned edges of the ridges on one side are exposed in the form of a bluff wall, and the smoother and more gently sloping side of the second ride on the other; but just before reaching the mouth of Lost Creek, it flows along a synclinal valley, that is, the strata dip in opposite directions from each side of the river channel. A long ridge of conglomerate, which is well shown in the background of photograph XIX., extends down from the direction of the Wasatch Range, nearly northeast and southwest, and inclining northeast 5° to 10°. At this point the Weber River, instead of continuing in the synclinal valley, cuts through the ridge, isolating a portion about a half a mile in length, and forming the high chasm or gorge which is called the "Narrows." After passing through this ridge, the Weber receives the waters of Lost Creek and then makes an abrupt bend to the south, exposing a vast thickness of the older rocks in a nearly vertical position. These rocks extend down the Weber for about four miles, where the strata abruptly change from the nearly vertical to a nearly horizontal position.

Photograph XIX. is a distant, and photograph XX. a near view of a remarkable exhibition of limestone rock, called "Serrated Rocks" or "Devil's Slide." I shall make this point clearer to the reader by giving additional description of the rocks as shown in photograph XIX. In the background on the left as you look at the picture, you may see the high, bluff, castellated rocks, which incline at a moderate angle. This is the isolated portion of the conglomerate ridge which extends down from the direction of the Wasatch Range and is cut off by the Weber River, forming a gorge or chasm which is commonly known as the "Narrows."

In descending the Weber River, this isolated portion is observed on the right or north side of the road, and the river on the opposite side; a portion of the ridge can be seen just back of the vertical limestone. On the left, in the picture again, may be seen a depression or valley; this is Lost Creek, and also just in the rear, a short ridge extending up to the summit, which has a square fortification-like appearance. The summit rock is the conglomerate, resting in a nearly horizontal position on the nearly vertical edges of slaty limestones and marls. These limestones are of a grayish ash color, very brittle, fracturing in every direction, so that the valley and sides of the hills are covered thickly with the debris. Just as the road emerges from the "Narrows," it passes through a deep, artificial cut in these limestones, in which their characters are well shown. At first they appear in thin slaty layers, then continue to increase in thickness toward the foreground until the "Serrated Rocks" shown in the picture become massive beds. The "Serrated Rocks" cross the river near the bridge and are quite well shown on the opposite side, though not so conspicuously. It would appear, therefore, that the Weber River, after making the bend near the mouth of Lost Creek, ploughed its channel through these vertical ridges at right angles to them.

These limestones I have regarded as of Jurassic age; I did not observe any rocks of more recent date conforming to them, but I think that Cretaceous beds can be found, holding the same vertical position, underneath the conglomerate of the north side of the "Narrows." This is the second instance of absolute unconformability that I have observed along the road. About two miles west of Bear River City, beds belonging to the Wasatch group appear to rest on the vertical edges of the Bear River group. At this locality I have not seen the more recent formations, but I have no doubt that a more careful examination up the valley of Lost Creek would show the exact relations of the conglomerates to the older Tertiary formations. We have here therefore, as shown in our photograph, the conglomerates reposing upon the vertical edges of Jurassic limestone. As we pass down the Weber Valley across the vertical edges of these ridges, we come next to a series of mud shales, with ripple marks, some layers of very white sandstone and a thick bed of hard, red sandstone, destined to take the highest rank among the building stones of Utah. It can easily be wrought into any desirable shape for culverts, fronts of buildings, caps and sills, etc. It is transported all along the line of the

road, even beyond Green River. The red sandstones for the abutments of the bridge, shown in photograph XII., were obtained at this locality.

Then comes a vast thickness of gray and dark gray, more or less cherty limestone, and then a great thickness of quartoze rocks with beds of limestone. The distance from the mouth of Lost Creek to the lower limit of the series of vertical rocks is about three miles, so that we have here a thickness of about two miles of rocky strata exposed to the scrutiny of the geologist.

But the most marked feature, and one which will always attract the attention of the traveler, are those projecting masses of limestone as shown in photograph XX. The beds are from 15 to 20 feet in thickness, and rise to the height of 1,000 feet or more upon the almost perpendicular sides of the mountain. They appear to have been thrust out of the mountain side, and hence many people have regarded them as dikes or outbursts of igneous material. The beds of limestone are about 200 feet apart, and the immediate space, which was composed of softer material, has been worn out by atmospheric agencies, and smoothed down and grassed over and covered with flowers and small shrubs.

In the "Narrows," or "Wilhelmina Pass," as it is sometimes called, is a lone pine tree, which will always form a noted landmark in this region. It is called the "Thousand Mile Tree," because it is just 1,000 miles west of Omaha; but long before a railroad was dreamed of in this region, it stood here as a sort of lonely sentinel guarding the pass, a solitary spectator of the wild grandeur around it.

The Weber Cañon is one of the most interesting regions along the line of the road, and if we were to describe it in detail, it would form a volume. The river is well shown in photograph XIX. as it rushes swiftly down the cañon for about 40 miles, until it emerges into the more open country about Salt Lake. About two miles below the "Serrated Rocks," we have the almost vertical walls of gray limestone rising to the height of 1,000 to 1,500 feet above the road, presenting a remarkably wild and rugged appearance. Photograph XXII. exhibits the external features of the carboniferous limestones of this region very finely; "Finger Rock" is a projecting portion of a limestone ridge. Photograph XXII. exhibits one of the most attractive views in the Weber Cañon. The river dashes along close by the railroad with the lofty walls of limestone on either side, and is fluxed from its course by a ridge, through which the waters have

cut their way. When the chasm was too narrow to admit of the passage of the road, ridges have been tunneled. In our illustration we see the upper entrance of Tunnel No. 3 through a ridge 550 feet in length. The rocks here incline on the left side of the Weber about 10° nearly north, while on the opposite side the strata dip about south 3° to 5°, as if the valley was an anticlinal one. Then again a little lower down, the valley would appear to be monoclinal, the strata on the right side of the river inclining 20° south, and on the opposite side, though presenting a nearly vertical point, inclining south also. This cherty limestone extends to Morgan City, where it disappears.

In summing up the geological features of the Weber Cañon, from the "Narrows" to the Wasatch Range, I regard the ashen-gray, brittle limestone as of Jurassic age; the red sandstone and a portion of the quartzite as possibly Triassic, and the cherty limestones shown in photograph XXII. as of Carboniferous age. So far as my knowledge extends there are no unchanged sedimentary rocks in Utah of older date than the Carboniferous; I would not say that they do not exist at all, for there is ample room for them, but I have never seen any along the line of the road, or in any other portion of the Territory, although the sedimentary formations have a thickness of 15,000 to 20,000 feet.

At Weber Station we emerge from the upper cañon into a broad expansion of the valley, filled with little villages and farm-houses; Morgan City is the principal town, and is located near the upper end of the valley. The soil is of great fertility; the hills on either side are smoothed off, and covered thickly with loose material and vegetation. The high vertical exposures all disappear; the Wasatch Range, which lifts its crest far above the surrounding country, and lends such a picturesque view to the background, trends nearly north and south; even the foot hills of this range are so smoothed off and covered with drift and then with grass, that the underlying basis rocks cannot be seen. The industry displayed by the Mormons in this valley is worthy of respect. The little streams are employed to irrigate the rich bottom lands, which produce abundantly, and the houses look neat and comfortable. The elevation is still too great for the successful cultivation of fruit. The varieties of trees are mostly confined to the cotton-wood, although from Echo City down the valley, we meet with small dwarf oak, boxelder, striped maple and choke cherry trees.

The evidence is quite clear that, from Morgan City to the entrance of Wasatch Cañon, a lake once extended, the waters of which filled up the valley, deposited thick beds of sediments, and finally rounded off the hills, and strewed the side of the mountains with loose debris. Prior to this last lake period, was another lake, which is shown in the underlying rocks which are exposed in various portions of the valley, whitish, fine, gray and rusty yellow sandstones, hard enough for building purposes, with flesh colored marls, probably of Pliocene age, and resembling very closely in many respects the more recent Tertiary beds in the Platte Valley. These recent beds incline east or southeast, and from this fact we learn that some of the later movements of these mountain ranges have been of comparatively modern date.

It seems, therefore, that all the more recent formations which are observed in the immediate valley of Salt Lake, also occur high up in the valleys of the rivers which flow into this great basin; that the waters, extending back in time far into the Tertiary period, set up, as it were, into these valleys, depositing the same kind of sediments. We have in the Salt Lake Valley thick beds of Pliocene sands, sandstones and marls, with some fossils, a few vertebrate remains, and a species of land shell which cannot be distinguished from a snail found in the "Bad Lands" of Dakota. This formation, which I have named the "Salt Lake Group," once occupied the whole valley without doubt, has been largely worn away, but all along the flanks of the mountains that surround the valley, these beds may be seen inclining at a small angle, say 5° to 10°. Then again the same superficial deposits of drift and loose sand, which composed the terraced hills, are all identical. The terraces in Salt Lake Valley which form a conspicuous feature, are found high up the river valleys and about the same level, showing pretty clearly that they were all synchronous.

Leaving Weber Station, we glide down the open valley with great rapidity for about 10 miles, when we enter Wasatch Cañon and pass through "Devil's Gate," which is so well shown by photograph XXIII. Not the least attraction to the traveler is the roar of these waters of the Weber as they roll over the immense masses of rock with the rush of a mountain torrent. For four miles we are enclosed within nearly perpendicular walls of gneiss 2,000 feet high, which form the central portion of the Wasatch Range. The river really cuts the range at right angles.

The rocks are beautifully banded everywhere; there are also coarse aggregations of quartz and feldspar with large masses of tourmaline, and all through the gneiss are seams of feldspar and quartz of various thicknesses. All along the sides of the channel, high up on the steep mountain flanks are vast deposits of boulders and fine sand. Soon we emerge from partial darkness into the clearer light of one of the most beautiful, broad, productive valleys in the world, and into full view, also, of Great Salt Lake.

From Omaha to Great Salt Lake Valley, a distance of 1,025 miles, the road passes over metamorphic rocks but twice; through the Laramie Range, west of Cheyenne, about 15 or 20 miles, and then through the Wasatch Range four miles; that is, in the whole distance, the road passes over about 20 miles of what is usually regarded as mountain rocks or granites. All the rest are unchanged rocks and mostly of Cretaceous or Tertiary age.

From Uintah Station to Promontory Point is not the least attractive portion of our route, although we have emerged from the deep gorges with the overhanging walls on either side. On our right, the Wasatch Range continues with us most of the way, rising to a majestic height with a pleasing variety in its outline; all along the sides we can see the various cañons through which streams of pure mountain water pour into the valleys, and if we were to take the time to follow them up to their heads, we should find most abundant material for pleasure and instruction. On our left, the quiet waters of the lake stretch far beyond the limits of our vision like a vast inland sea. Broad plains, well cultivated fields, thriving villages and neat farm-houses meet the eye on every side. The mountains are full of mineral wealth, as silver and gold, and some of the mines are yielding good returns at this time.

But we will not delay at Ogden, Corinne, nor at any of the stations along our route which might attract our attention for a time. It is not the purpose of this volume to chronicle the scenes of murder and pillage, which form a part of the early history of all these railroad towns. Passing on to Promontory Point, we will rapidly glance at the hot springs, which can easily be detected from the railroad by the dense cloud of vapor which issues from them. For 100 yards or more around the springs, the surface is entirely destitute of vegetation and is covered with yellow oxide of iron. The waters are thoroughly impregnated with sulphur. The benches or

terraces all along the mountain sides are too perfect and remarkable to escape our attention. They surround the valley and formed water lines in past geological periods not remote. We shall also catch most favorable views of our great inland sea, with its numerous mountain islands lifting their summits far above the briny waters surrounding them.

Photograph XXVIII. presents a splendid view of the country near Promontory Point. The rocks are nearly all Carboniferous limestones and are very hard and cherty. In the foreground we have a fine view of a most remarkable trestle bridge 500 feet long and 87 feet high. Some of the heaviest work along the road was performed at Promontory Point in cutting through the tough limestones, and filling up the deep valleys. What added much to the labor also, was the fierce dispute between the rival companies, the Union Pacific and the Central Pacific, and millions of money were expended by the former in constructing a graded road. A close examination of our picture will show the cuts of the roads side by side. The ridges in the foreground and the higher mountains in the background are all composed of hard, cherty limestones which I regard of Carboniferous age. There is a vast area around Promontory Point which seems to be characterized by hills, ridges and mountains of limestone rising above the more superficial formations, as Pliocene marls, sands, sandstones and the immense deposit of quarternary sands and boulders, or what might be more properly named the terrace deposits. The appearance of the country around Promontory Point is desolate in the extreme. The surface is mostly loose sand with no vegetation but a few tufts of grass and sage-bushes. The whole region is one of interest to geologists, and to none others, and for the present we will leave it and return to Uintah or Ogden.

Ogden is the point of union of the two portions of the Pacific Railroad. The Utah Central starts from this point, and is nearly completed to Salt Lake City. Uintah is the point of departure for the stage lines to Salt Lake City, and the stage road will lead us along just under the shadows of the Wasatch Range. All along the base of the range to Salt Lake City, a distance of 35 miles, the country is dotted over with farmhouses and neat little villages, with fields of grain, orchards of fruit trees and mills of all kinds. Hundreds of little streams rush down the sides of the mountains and are diverted over the plains to perform their mission of irrigation. From Weber River southward for 20 miles the sides and

base of the Wasatch Mountains are covered thickly with superficial deposits of sand and boulders; not a trace of the older sedimentary rocks can be seen. I examined the valleys of the little streams for worn masses of limestone, and failed to find any. The terraces are very distinct, and add much to the beauty of the landscape. The erosion must have been very great in this valley. The Carboniferous rocks begin to make their appearance about 10 miles north of Salt Lake City, and continue to a greater or less extent all around the rim of the basin east of the city. I am inclined to believe all the formations known in the West occur on the sides of the range.

The surface of Salt Lake Valley has been rendered fruitful by the industry of the Mormons; like the greater portion of the mountain region, it was a vast sage-plain, and regarded as an irreclaimable desert; now, by irrigation, all kinds of cereals and roots grow luxuriantly, and there are no better apples, peaches, plums, grapes, etc., raised in America than here. There is no reason why it should not be as fine a wine producing region as California. The mildness of the climate and its favorable influence on all kinds of vegetable productions are due probably in part to the protection of the valley by ranges of mountains on every side, but mainly to its altitude, which is about 4,500 feet above the sea. It is not the purpose of this work to present a history of the Mormon settlements or of their religion. This has been done many times, until the subject has been exhausted. Neither is it the object to criticize or find fault with any person or class of persons. We can only say that we regard with great respect the Mormon people for the sacrifices they have made and the industry they have exhibited in changing this desert into a beautiful garden. Surely the desert has been made to "bud and blossom as a rose."

I have selected three pictures of this valley for this book, because I believed they would interest most of its readers.

Photograph XXVI. gives a fine view of one of the most beautiful cities on this continent. In the foreground may be seen the foundation of the Temple which the Mormon people confidently expect to erect in accordance with the plan already designed by their architect. It is estimated that the cost will not be far from $3,000,000. The stone of which it is to be built is the finest quality of gray granite, transported from Cotton-Wood Cañon in the Wasatch Mountains, about 20 miles distant, and is fully equal to the Quincy granite. The area of the foundation is

99 × 186 feet, and when completed in accordance with the design, the main building will be 100 feet high, with three towers on each end, the middle ones rising to a height of 200 feet above the ground, making one of the finest and most imposing structures in America.

In the centre of the picture the reader can catch an imperfect view of President Young's fine buildings. The one with the gable ends is the residence of his wives, and just beyond is his own splendid mansion. At the foot of the mountains, Camp Douglas, the United States Military Post, is dimly visible, located in one of the most desirable spots in the West. The view from this point across the valley is always beautiful in the extreme, but late in the afternoon of a clear summer day, as the sun descends behind the western mountains, clothing lake and valley in a flood of golden light, the scene baffles all description, and defies the painter and the poet. In the background, the characteristic outline of the Wasatch Mountains is well shown with several of the more noted cañons. The depression that we see in the distance at the right of the picture, is Parley's Cañon, through which the great overland road passes, along which so many thousands of pilgrims have marched their slow and toilsome way, and at last emerged with rejoicing into the full light and vision of the promised land. The nucleus of these mountains is gneiss and granite, and, indeed all kinds of metamorphic rocks, flanked by most of the sedimentary rocks of this region.

Photograph XXIV. is a fine view of City Creek Cañon, with the waters of City Creek tumbling down the mountain side. Salt Lake City is mainly supplied with water from this stream. It takes its rise about eight miles above this point in the region of perpetual snow, and the waters that flow down are always abundant, cool and pure as crystal. The sides of the mountains are covered with a dense growth of pine, spruce and balsam fir, and here and there groups of aspen poplars, with a great variety of shrubs. Thousands of beautiful flowers deck the mountain sides in the season of summer. Although my reader will, without hesitation, agree with me that this is a most beautiful view, and may long to climb the rocky sides of the cañon and drink of the pure water, I will inform him that this is only one of hundreds that could be found all over Utah, many of which are far more rugged, picturesque and beautiful than the one represented in the picture before him. The rocks shown in the photograph are all gneissic granite.

One of the most conspicuous buildings which attract the eye of the traveler as he enters the city, is the Tabernacle, which is well shown in photograph XXVII. The building is oblong in shape and is 250 feet in length by 150 in width. The oval shaped dome is supported by 46 pillars which serve as a sort of wall, from which the roof springs in an unbroken arch, forming the largest self-sustaining roof on the continent. This building will seat comfortably 7,000 people, and 10,000 may be gathered there on extraordinary occasions. The writer attended one of the semi-annual gatherings of the Mormons two years ago, when the Tabernacle was crowded to its utmost capacity, and the acoustic properties of the building were so fine that the speakers could easily make themselves heard in any portion of it. At one end of this building is a splendid organ, commenced four years ago, and not yet completed, which, when finished, will form the second or third in size in America; its tones are powerful, but rich and soft, filling the immense dome with its music. The reader will also catch a distant view of Salt Lake, and farther on the dim outlines of the mountains that wall in the valley on all sides.

A nearer view of the mountains is shown in photograph XXV., which gives a well defined outline of one of the most prominent peaks in the range. Brigham Young's woolen mills appear in the foreground; on the left are the recent sandy beds which underlie the terraces and form the foot hills along the immediate base of the mountains. This picture also presents a close view of a portion of the valley with its cultivated fields and farm-houses and the abrupt, wall-like character of the mountain ranges that surround it. At the right of the picture, the terraces can be seen somewhat dimly. Originally the area now occupied by this beautiful city was a sage-plain without a tree, or shrub but the wild sage, and with every indication of sterility. Now, elegant gardens with abundant fruit and shade trees surround fine dwellings, and along each side of the broad streets is a fine stream of mountain water, bordered with a row of flourishing shade trees.

But we must not omit to mention in this connection the warm springs which are located about a mile north of the city. They issue from the limestone rocks near the foot of the mountains; all around the place are tufa-like incrustations of sufficient hardness to be used for walls and fences. The baths at this place are the most grateful I have ever enjoyed, and I cannot well conceive of a more desirable locality for invalids in a

sanitary point of view. The following analysis of the water, made by Dr. Charles S. Jackson, of Boston, is posted on the walls of the bathing-house, which any one can have the privilege of reading or copying:

"Three fluid ounces of the water, on evaporating to entire dryness in a platina capsule, gave 8.25 grains of solid dry saline matter:

"Carbonate of Lime and Magnesia	0.240	1.280
Peroxide of Iron	0.040	0.208
Lime	0.545	2.907
Chlorine	3.454	18.421
Soda	2.877	15.344
Magnesia	0.370	2.073
Sulphuric Acid	0.703	3.748
	8.229	43.981

"It is slightly charged with hydro-sulphuric acid gas and with carbonic acid gas, and is a pleasant, saline, mineral water, having the valuable properties belonging to saline sulphur springs."

The above is a true copy of the analysis, and the reader can extract for himself whatever information of value it may contain.

About three miles north of the city are the hot springs, which are well worth the examination of the traveler. The water boils up from beneath beds of limestone at the base of the mountains, and it is only necessary to thrust the hand into it to ascertain that it is boiling hot. Meat is readily cooked in it, and eggs will be ready for the table in three minutes. The dense column of steam that rises perpetually, will always point out the locality of the springs. Quite a large volume of water issues forth, forming a stream four or five feet in width and six inches in depth. It flows into a beautiful lake not far distant to the west, called Hot Spring Lake. This lake is supposed to be supplied to some extent with water from hot springs beneath the surface. Still the hot water is not sufficient to prevent the existence of some kinds of excellent fish, among them fine large trout. Springs, which, if they existed on the Atlantic Coast, would be of great value, are so common throughout all this region that they attract but little attention. Hot, warm and cold springs frequently issue from the ground only a few yards apart.

In no portion of the inland West will the traveler so delight to linger and enjoy the novelty and beauty of the scenery and the exhilirating

influence of the atmosphere. But before leaving this pleasant region we may devote a paragraph at least to the remarkable inland sea which gives the name and fame to Central Utah.

More than a century and a half ago rumors came over the mountains into the valley of the Mississippi, that there existed a large lake of salt water far away in the unknown wilderness, west of the Rocky Mountains. As far back as 1689, Baron La Hontan, a French officer, (who started a French colony in Newfoundland,) published an account of his travels up the Mississippi, to which is attached the rude outline map on which is located this lake, or sea. While making his passage up the Mississippi, he was visited by a "Cacique" (of the Gnacsitares) with 400 of his own subjects and four Mozeemlek savages. He says that the four slaves gave him a description of this country, and drew a map on a deer skin as it is given in his book.

"The Mozeemlek nation is numerous and puissant. The four slaves of that country informed me, that at a distance of 150 leagues from the place where I then was, their principal river empties itself into a salt lake of 300 leagues in circumference, the north of which is two leagues broad; that the lower part of the river is adorned with six noble cities, surrounded with stone cemented with fat earth; that the houses of these cities have no roofs, but are open above, like a platform; that there are above 100 towers, great and small, round that sort of sea, which the people navigate with boats; that the people of that country made stuffs, copper axes and several other manufactures, etc."

We may regard these statements of La Hontan as the first faint glimpses in history, not only of the Great Salt Lake, and surrounding country, but also of the curious ruins in Southern Utah and along the Rio Colorado. There is here an unexplored field awaiting the investigations of the patient antiquarian, and it is doubtful if any portion of our country would yield results more interesting and important to the student and archæologist.

Although such streams as the Jordan, Weber and Bear Rivers, with numerous smaller ones, have been for ages pouring a vast volume of water into this lake, it is now well known that it has no visible outlet; the question naturally arises: What becomes of all the water thus gathered into this area? We believe that it all disappears by evaporation. It seems, however, that of later years the evaporation has not been going on as

rapidly as in former times. It is stated by the railroad engineers, that the waters of the lake have risen nine vertical feet since 1864, and the general impression is, that all the lakes of the West are rising more or less.

We might note in this connection many changes which this valley must have been subjected to since the present configurations of the surface were outlined by the elevation of the mountain chains. Several times this valley must have been filled high up on the mountain sides with water, water, too, with but very little of that saline character which it possesses at this time. Indeed, I am convinced that, while the lake itself is not of modern origin, yet as a salt lake in its present condition, it is of comparatively recent date. We find all along the flanks of the mountains, and high up in the valleys of the ravines opening into this basin, groups of strata hundreds of feet in thickness, which are doubtless of fresh water origin, dating back into the Pliocene or Upper Tertiary period. Then these beds have been disturbed by the elevations of the mountains, showing that while these ranges formed shore lines for the lakes of this period, they did not reach their present height until after the deposition of these Tertiary beds. Resting upon them and apparently deposited after the upheaval movements had ceased, are heavy beds of sand and gravel, and the flanks of the mountains all around the valley, as well as the sides of the mountains in the islands of the lake, reveal numerous water lines, showing most clearly the elevations to which the waters of the lake must have reached in later geological times. We can hardly suppose that during these periods the waters here were sufficiently salt to differ from the other lakes in the West. I am inclined to the belief, therefore, that the saline materials of a vast area have been concentrated by time into the basin now occupied by Salt Lake, and that it is owing to its partial evaporation that its water is become so salt.

Let us for a moment take a bird's eye view of the great inland basin of which Salt Lake Valley forms only a part. We shall find that what is termed the Great Basin of the West comprises the vast area enclosed by the Wasatch Mountains on the east, and the Sierra Nevada on the west, the crest or water divide of the Columbia on the north, and that of the Colorado on the south. We shall also observe that this great region has no visible outlet; that it is composed of a multitude of smaller basins or valleys, each of which has its little lakes, springs and water courses, their surplus water either evaporating or sinking beneath the surface. If we

examine the elevations in this region, we observe a wonderful uniformity in the surface of the valleys and find that none of them are much above the level of the waters of Great Salt Lake. As Captain Stansbury has remarked:

"These plains are but little elevated above the present level of the lake, and have beyond question at one time formed a part of it; an elevation of but a few feet above the present level of the lake, would float this entire flat to a great distance, thus forming a vast inland sea."

It seems probable also, that at a comparatively modern period, the briny waters did spread out over a much larger area than at present, for both Fremont and Stansbury make frequent mention of large tracts covered with an incrustation of salt. The latter, in describing the broad plain country to the west of Great Salt Lake, says:

"The first part of the plain consisted simply of dried mud, with small crystals of salt scattered thickly over the surface. Crossing this, we came upon another portion of it, three miles in width, where the ground was entirely covered with a thin layer of salt in a state of deliquescence, and of so soft a consistence that the feet of our mules sank at every step into the mud beneath. But we soon came upon a portion of the plain where the salt lay in a solid state in one unbroken sheet, extending apparently to its western border. So firm and strong was this unique and snowy floor, that it sustained the weight of our entire train, without in the least giving way or cracking beneath the pressure. Our mules walked upon it as upon a sheet of solid ice. The whole field was crossed by a network of little ridges, projecting about half an inch, as if the salt had expanded in the process of crystalization. I estimated this field to be at least seven miles wide and ten miles in length. How much farther it extended northward I could not tell, but if it covered the plain in that direction as it did where we crossed, its extent must have been very much greater. The salt, which was very pure and white, averaged from one-half to three-fourths of an inch in thickness, and was equal in all respects to our finest specimens for table use. Assuming these data, the quantity that here lay upon the ground in one body, exclusive of that in a deliquescent state, amounted to over four and a half millions of cubic yards, or about one hundred millions of bushels."

Areas of greater or less extent, covered with this saline incrustation, occur in numerous localities, so that we may infer that in all probability,

at no very distant period in the past, the salt lake extended either connectedly or in isolated portions over the greater part of the Great Basin.

It would be a most interesting subject to trace the history of this wonderful lake far back in the geological past; from the records which have been left in the sediments, I have obtained comparatively few facts as yet, but they seem to be quite conclusive, and I believe that each successive step in the changes which this great region has undergone can be interpreted with accuracy from the records left in the surface deposits, if they could be studied in detail.

One of the most conspicuous features in this basin, is the system of terraces or benches which borders the valleys as well as the streams. These terraces seem to form an independent system in this basin, disconnected both in regard to time and the causes that produced them, from those so well known along the Missouri and Columbia Rivers.

Not only do they seem to be universal over this great basin, but they are all of about the same level. I have never observed more than two or three of these benches well defined, but Captain Stansbury speaks of counting 13 successive terraces at the northern end of the lake, the highest about 200 feet above the valley.

In volume II. of the Pacific Railroad Reports, page 97, there is a most interesting note in regard to these remarkable shore lines, which I am sure will be as instructive to those who may read this volume, as it has been to me:

"The old shore lines existing in the vicinity of the Great Salt Lake present an interesting study. Some of them are elevated but a few feet (from five to twenty) above the present level of the lake, and are as distinct and well defined as its present beaches, whilst their magnitude and smoothly worn forms as unmistakably indicate the levels which the waters maintained at their respective formations for very considerable periods. In the Tuilla Valley, at the south end of the lake, they are so remarkably distinct and peculiar in form and position that they attracted the attention of the least informed teamsters of my party, to whom they appeared artificial. From these beaches the Tuilla Valley ascends gradually toward the south, and in a few miles becomes blocked up by a cross-range of mountains, with passages at either side leading, however, over quite as remarkable beaches, into what is known to the Mormons as Rush

Valley, in which there are still small lakes or ponds, once, doubtless forming part of the Great Salt Lake.

"The recessions of the waters of the lake from the beaches at these comparatively slight elevations, must have taken place within a very modern geological period, and the volume of the water of the lake at each subsidence—by whatever cause produced, whether gradual or spasmodic—seems as plainly to have been diminished; for its present volume is not sufficient to form a lake of even two or three feet in depth over the area indicated by these shores, and, if existing, would be annually dried up during the summer.

"These banks are not peculiar to the vicinity of this lake of the basin, but were observed near the lakes in Franklin Valley, and will probably be found near other lakes and in the numerous small basins, which united form the Great Basin. They clearly seem to have been formed and left dry within a period so recent that it would seem impossible for the waters which formed them to have escaped into the sea, either by great convulsions opening passages for them, or by the gradual breaking up of the distant shore (rim of the basin), thus draining them off, without leaving abundant records of the escaping waters, as legible at least as the old shores they formed.

"But high above these diminutive banks of recent date, are seen on the mountains to the east, south and west, and on the islands of Great Salt Lake, formations preserving apparently a uniform elevation as far as the eye can extend—formations, which hastily examined, seem no less unmistakably than the former to indicate their shore origin. They are elevated from 200 or 300 to 600 or 800 feet above the present lake, and may on careful examination afford the means of determining the character of the sea by which they were formed, whether an internal one, subsequently drained off by the breaking or wearing away of the rim of the basin, or an arm of the main sea, which with the continent has been elevated to its present position and drained by the successive steps indicated by these shores."

We might go back to the Middle or Upper Tertiary period, when the light sandstones, clays and marls which are now well shown on the margins of the mountains near Salt Lake City, at Promontory Point and in the Weber Valley, must have once extended over the greater portion of the basin, with a thickness of 1,000 feet or more. These rocks

which I denominate the Salt Lake group, have been disturbed more or less by the later movements of the mountain range, but were deposited evidently since the present outline of the surface of the country was marked out, and the mountains were elevated so as to form shore lines for the waters of the period. These beds contain a species of Helix or land snail, which is undistinguishable from *H. Leidyi*, a fossil peculiar to the Miocene formations of White River, Dakota. I have no doubt some interesting mammalian remains will be found in these beds when they have been carefully searched. These sediments were undoubtedly deposited in fresh waters.

But let us glance for a moment at the events which must have taken place at a much later date, probably during what geologists regard as the Quarternary period, or the one that immediately precedes the present epoch and graduates into it. All over the Great Basin, from the Wasatch Mountains to the Sierra Nevada and in the valleys of the streams that flow into the basin, are immense deposits of drift, composed of water-worn pebbles, passing up into fine sands and clays. In the valley of Salt Lake, and especially in that of the Weber River, these drift deposits possess a thickness of several hundred feet, and of these materials the terraces are formed. Near Salt Lake City, in digging a well, were found in these deposits, 40 feet below the surface, fresh-water shells and on the north side of the lake, where these deposits are very largely exhibited, the cuts in the railroad, through the gravel and sands, reveal the greatest abundance of fresh-water shells, showing that at this time the physical conditions were unusually favorable for the existence of fresh-water molluscous life. So far as I could ascertain, these conditions do not exist at the present time, or if they do, it must be only to a limited extent.

I am indebted to the kindness of Mr. George W. Tryon, Jr., for the identification of the species obtained from this drift:

1. *Fluminicola fusca.* This species seems to have been very abundant; it exists at the present time in the mountain streams.
2. *Pomatiopsis Cincinnatiensis.*
3. *Amnicola limosa.*
4. *Valvata sincera.*
5. *Limnea desidiosa.*
6. *Limnea catiscopium.*

From these observations I infer that a vast fresh-water lake once occupied all this immense basin; that the smaller ranges of mountains

were scattered over it as isolated islands, their summits projecting above the surface: that the waters have gradually and slowly passed away by evaporation, and the terraces are left to reveal certain oscillations of level and the steps of progress toward the present order of things; and that the briny waters have concentrated in those lake-basins, which have no outlet. The entire country seems to be full of salt springs, which have in all probability contributed a great share to the saline character of the waters.

But I cannot pursue this subject farther in this volume, and we must take reluctant leave of this beautiful valley and direct our attention for a moment to the interval, that separates it from the Pacific Coast. As soon as we leave Promontory Point, we find ourselves in a different country, geologically as well as geographically. As far as the eye can reach, small detached mountain ranges seem to rise out of the plain; since they attained nearly or quite their present elevation, they have all been surrounded by one vast lake of waters, in which were deposited the light sands, clays and chalky infusorial earths, which seem to jut up against their base in an undisturbed position. Upon these modern Tertiary beds are vast deposits of still more recent soil and gravel, which must have been transposed and distributed over these plains by water. We will glide down Carson's Valley by the Humboldt River, across the great American desert, with its covering of snow-white salts and its hot springs, and hasten to the Sierra Nevada, one of the most wonderful ranges of mountains in the world.

We present to our readers but one illustration of this remarkable scenery, photograph XXIX., as a foretaste of what may come hereafter, if success attend our efforts in this enterprise.

Donner Lake, which is sometimes called the "Gem of the Sierras," is situated on the very summits of the Sierra Nevada, and forms one of those reservoirs of water, which are derived from mountain springs and the melting of snows and are very numerous in this range; they are always remarkable for their picturesque beauty. This lake is in full view from the railroad, and the traveler can look down upon it as he is crossing the summit.

In the foreground, the massive granite rocks, smoothly rounded by atmospheric agencies, are well shown. The winter snows fall here to a very great depth; they reached 40 feet in the aggregate during the season 1867–8, and in one winter 57 feet of snow fell on these mountains.

Our illustration conveys a clear idea of the succession of snow-sheds and tunnels through which the Central Pacific Railroad runs in crossing the Sierra Nevada. The tunnels are 13 in number, and the largest is near the summit, more than 7,000 feet above the sea. It is 1,659 feet through massive granite; of the other tunnels, the shortest is 92 and the longest 870 feet.

The snow sheds are substantial structures, built of sawed and round timber, at a cost of $10,000 per mile. There are 40 miles of these sheds now completed, and they are so constructed that the immense avalanches, which so often slide down the sides of the mountains in the spring, pass over them and fall into the chasms below. These tunnels and snow-sheds are very important to the road, and the latter have proved a protection from the snows, but they hide from view some of the most magnificent scenery in the world.

As the traveler descends the western slope of the Sierra Nevada, he will see on either side of the railroad the most remarkable exhibitions of hydraulic gold-mining in America; no examples in Colorado or New Mexico can compare with the gigantic scale on which this operation is here developed. Photograph XXX. was taken at Dutch Flat in full view from the railroad, and presents a clearer conception of this process, than could be conveyed to the mind by pages of description. Within the radius of five or six miles, all to be seen from the railroad, are a number of pretty little mining towns, bearing such euphonious names as "You Bet," "Red Dog," "Little York," "Dutch Flat" and "Gold Run." They are quite flourishing villages, some having about 2,000 inhabitants. Mining ditches can be seen on every side, conveying large and rapid streams of water in long narrow flumes (or telegraphs, as they are called by the miners) over the claims to be worked. To the flume is attached the hose by which the water is thrown against the banks of sand and gravel with great power, washing down areas of gravel from 100 to 300 feet in thickness. Many miles of these ditches and flumes have been built in these mining regions and the surface of the country entirely changed; one large ditch was constructed at a cost of a million of dollars.

Cements or conglomerates form one of the most conspicuous features of the geology of the Sierra Nevada Mountains, and I have reserved their study for the contemplated second volume, illustrating the Central Pacific Railroad from Ogden to San Francisco.

CHAPTER VII.

THE ANCIENT LAKES OF WESTERN AMERICA: THEIR DEPOSITS AND DRAINAGE.

By J. S. Newberry, LL. D.

THE wonderful collections of fossil plants and animal remains brought by Dr. Hayden from the country bordering the Upper Missouri have been shown by his observations, and the researches of Mr. Meek, to have been derived from deposits made in extensive fresh-water lakes; lakes, which once occupied much of the region lying immediately east of the Rocky Mountains, but which have now totally disappeared. The sediments that accumulated in the bottoms of these old lakes show that in the earliest periods of their history they contained salt water, at least that the sea had access to them, and their waters were more or less impregnated with salt, so as to be inhabited by oysters and other marine or estuary mollusk. In due time the continental elevation which brought all the country west of the Mississippi up out of the wide spread Cretaceous sea, raised these lake-basins altogether above the sea level and surrounded them with a broad expanse of dry land. Then ensued one of the most interesting chapters in the geological history of our continent, and one that, if fairly written out, could not fail to be read with pleasure by all intelligent persons. The details of this history are however, in a great measure, yet to be supplied; inasmuch as the great area of our Western possessions is still but very partially explored, and it is certain that it forms a great treasure-house of geological knowledge, from which many generations will draw fresh and interesting material before its riches shall be exhausted.

The enlightened measures adopted by our Government for the exploration of the public domain, the organization and thorough equipment of the numerous surveying parties that have traversed the region west of the Mississippi within the last 20 years, together with the still more extensive explorations by private enterprise of our great mining districts, have resulted in giving us materials from which an outline sketch can now be made that may be accepted in all its essential particulars as accurate and worthy of confidence.

It has happened to me to be connected with three of the Government surveys, to which I have referred, and to spend several years in traversing the great area lying between the Columbia River and the Gulf of Mexico. The observations which I have made on the geological structure of our Western Territories, supplement in a somewhat remarkable way those made by Dr. Hayden, so that taken together, our reports embody the results of a reconnoissance stretching over nearly the whole of our vast possessions west of the Mississippi.

Our knowledge of the geology of this region has also been largely increased by the no less important contributions of other explorers. Among those who deserve most honorable mention in this connection are Mr. George Gibbs, to whom we are indebted for most that we know of the geology of Washington Territory ; to Professors W. P. Blake and Thomas Antisell, to Professor Whitney and the other members of the California Geological Survey ; to Baron Richthofen, the lamented Rémond, Drs. Shiel, Wislizenus, and others.

The results obtained by the last, largest and best organized party which has been engaged in Western explorations, that of Mr. Clarence King, have not yet been given to the public, but from an examination of some of the materials which are to compose the reports of this expedition, I feel justified in saying, that it will prove to be among the most important of all the series of explorations of which it forms part ; and that the published results of this expedition will be not only an important contribution to science and our knowledge of our own country, but a high honor to those by whom the work has been performed, and to the Government, by which it was organized.

Without going into details or citing the facts or authorities on which our conclusions rest, I will in few words give the generalities of the geological and topographical structure of that portion of our continent

which includes the peculiar features that are to be more specially the subject of this paper.

It is known to most persons that the general character of the topography of the region west of the Mississippi has been given by three great lines of elevation which traverse our Territory from north to south: the Rocky Mountain Belt, the Sierra Nevada and the Coast Ranges. Of these the last is the most modern, and is composed, for the most part, of Miocene Tertiary rocks. It forms a raised margin along the western edge of the continent, and has produced that "iron bound coast" described by all those who have navigated that portion of the Pacific which washes our shores.

Parallel with the Coast Mountains lies a narrow trough which, in California, is traversed by the Sacramento and San Joachin Rivers, and portions of it have received their names. Further north, this trough is partially filled, and for some distance, nearly obliterated by the encroachment of the neighboring mountain ranges, but in Oregon and Washington it reappears essentially the same in structure as further south, and is here traversed by the Willamette and Cowlitz Rivers.

These two sections of this great valley have now free drainage to the Pacific, through the Golden Gate and the trough of the Columbia, both of which are channels cut by the drainage water through mountain barriers that formerly obstructed its flow, and produced an accumulation behind them that made these valleys inland lakes; the first of the series I am to describe of extensive fresh-water basins that formerly gave character to the surface of our Western Territory, and that have now almost all been drained away and disappeared.

East of the California Valley, the Sierra Nevada lies like a lofty mountain chain reaching all the way from our northern to our southern boundary. The crest of the Sierra Nevada is so high and continuous that for 1,000 miles it shows no passes less than 5,000 feet above the sea, and yet, at three points there are gate-ways opened in this wall, by which it may be passed but little above the sea level. These are the cañons of the Sacramento (Pit River), the Klamath and the Columbia. All these are gorges cut through this great dam by the drainage of the interior of the continent. In the lapse of ages the cutting down of this barrier has progressed to such an extent as almost completely to empty the great water basins that once existed behind it, and leave the interior the arid waste that it is—the only real desert on the North American Continent.

The Sierra Nevada is older than the Coast Mountains, and projected above the ocean, though not to its present altitude, previous to the Tertiary and even Cretaceous ages. This we learn from the fact, that strata belonging to these formations cover its base, but reach only a few hundred feet up its flanks. The mass of the Sierra Nevada is composed of granitic rocks, associated with which are metamorphic slates, proved by the California Survey to be of Triassic and Jurassic age. These slates are traversed in many localities by veins of quartz, which are the repositories of the gold that has made California so famous among the mining districts of the world.

East of the Sierra Nevada we find a high and broad plateau, 500 miles in width, and from 4,000 to 8,000 feet in altitude, which stretches eastward to the base of the Rocky Mountains, and reaches southward far into Mexico. Of this interior elevated area the Sierra Nevada forms the western margin, on which it rises like a wall. It is evident that this mountain belt once formed the Pacific Coast; and it would seem that then this lofty wall was raised upon the edge of the continent to defend it from the action of the ocean waves. In tracing the sinuous outline of the Sierra Nevada, it will be seen that its crest is crowned by a series of lofty volcanic cones, and that one of these is placed at each conspicuous angle in its line of bearing, so that it has the appearance of a gigantic fortification, of which each salient and re-entering angle is defended by a massive and lofty tower.

The central portion of the high table lands, to which I have referred, was called by Fremont the "Great Basin," from the fact that it *is* a hydrographic basin, its waters having no outlet to the ocean. The northern part of this area is drained by the Columbia, the southern by the Colorado. Of these the Columbia makes its way into the ocean by the gorge it has cut in the Cascade Mountains, through which it flows nearly at the sea level; while the Colorado flows to the Gulf of California through a series of cañons, of which the most important is nearly 1,000 miles in length, and from 3,000 to 6,000 feet in depth. In volume VI. of the Pacific Railroad Reports, I have described a portion of the country drained by the Columbia, and have given the facts that led me to assert that the gorge, through which it passes the Cascade Mountains, has been excavated by its waters; and that previous to the cutting down of this barrier these waters accumulated to form great fresh-water lakes, which

left deposits at an elevation of more than 2,000 feet above the present bed of the Columbia. Similar facts were observed in the country drained by the Klamath and Pit Rivers, and all pointed to the same conclusion.

In all this region I observed certain peculiarities of geological structure that have been remarked by most of those who have traversed the interval between the Sierra Nevada and the Rocky Mountains. In the northern and middle portions of the great table lands the general surface is somewhat thickly set by short and isolated mountain ranges, which have been denominated the "Lost Mountains." These rise like islands above the level of the plain, and are generally composed of volcanic or metamorphic rocks. The spaces between these mountains are nearly level, desert surfaces, of which the underlying geological structure is often not easily observed. Toward the north and west, however, wherever we come upon the tributaries of the Columbia, the Klamath or Pit Rivers, we find the plateaus more or less cut by these streams and their substructure revealed.

Here the underlying rocks are nearly horizontal, and consist of a variety of deposits varying much in color and consistence. Some are coarse volcanic ash with fragments of pummice and scoria. Others I have in my notes denominated "concrete," as they precisely resemble the old Roman cement and are composed of the same materials. In many localities these strata are as fine and white as chalk, and, though containing little or no carbonate of lime, they have been referred to as "chalk-beds" by most travelers who have visited this region. Specimens of this chalk-like material gave me my first hint of the true history of these deposits. These, collected on the head waters of Pit River, the Klamath, the Des Chutes, Columbia and elsewhere, were transmitted to Professor Bailey, then our most skilled microscopist, for examination. Almost the last work he did before his untimely death was to report to me the results of his observation on them. This report was as harmonious as it was unexpected. In every one of the chalk-like deposits to which I have referred, he found *fresh-water diatomaceæ*.

From the stratification and horizontality of these deposits, I had been fully assured that they were thrown down from great bodies of water that filled the spaces separating the more elevated portions of the interior basin, and here I had evidence that this water was fresh. Since that time a vast amount of evidence has accumulated to confirm the general view

then taken of the changes through which the surface of this portion of our continent has passed. From Southwestern Idaho and Eastern Oregon I have now received large collections of animal and vegetable fossils of great variety and interest. Of these the plants have been, for the most part, collected by Rev. Thomas Condon, of the Dalles, Oregon, who has exposed himself to great hardship and danger in his several expeditions to the localities in Eastern Oregon, where these fossils are found. The plants obtained by Mr. Condon are apparently of Miocene age, forming 20 to 30 species, nearly all new, and such as represent a forest growth as varied and luxuriant as can be now found on any portion of our continent.

The animal remains contained in these fresh-water deposits have come mostly from the banks of Castle Creek, in the Owyhee district, Idaho. The specimens I have received were sent me by Mr. J. M. Adams, of Ruby City. They consist of bones of the mastodon, rhinoceros, horse, elk and other large mammals, of which the species are probably in some cases new, in others identical with those obtained from the fresh-water Tertiaries of the "Bad Lands" by Dr. Hayden. With these mammalian remains are a few bones of birds and great numbers of the bones and teeth of fishes. These last are cyprinoids allied to *Mylopharodon*, *Micheilus*, etc., and some of the species attained a length of three feet or more. There are also in this collection large numbers of fresh-water shells of the genera *Unio*, *Corbicula*, *Melania* and *Planorbis*. All these fossils show that at one period in the history of our continent, and that geologically speaking quite recent, the region under consideration was thickly set with lakes, some of which were of larger size and greater depth than the great fresh-water lakes which now lie upon our northern frontier. Between these lakes were areas of dry land covered with a luxuriant and beautiful vegetation, and inhabited by herds of elephants and other great mammals, such as could only inhabit a well-watered and fertile country. In the streams flowing into these lakes, and in the lakes themselves, were great numbers of fishes and mollusks of species, which, like the others I have enumerated, have now disappeared. At that time, as now, the great lakes formed evaporating surfaces, which produced showers that vivified all their shores. Every year, however, saw something removed from the barriers over which their surplus water flowed to the sea and, in the lapse of time, they were drained to the dregs. In the Klamath lakes, and in San Francisco, San Pablo and Suisun bays, we

have the last remnants of these great bodies of water; while the drainage of the Columbia lakes has been so complete, that in some instances, the streams which traverse their old basins have cut 2,000 feet into the sediments which accumulated beneath their waters.

The history of this old lake country, as it is recorded in the alternations of strata which accumulated at the bottoms of its water basins, will be found to be full of interest. For while these strata furnish evidence that there were long intervals when peace and quiet prevailed over this region, and animal and vegetable life flourished as they now do nowhere on the continent, they also prove that this quiet was at times disturbed by the most violent volcanic eruptions, from a number of distinct centres of action, but especially from the great craters which crowned the summit of the Sierra Nevada. From these came showers of ashes which must have covered the land and filled the water so as to destroy immense numbers of the inhabitants of both. These ashes formed strata which were, in some instances, 10 or 20 feet in thickness. At other times the volcanic action was still more intense, and floods of lava were poured out which formed continuous sheets, hundreds of miles in extent, penetrating far into the lake-basins, and giving to their bottoms floors of solid basalt. When these cataclysms had passed, quiet was again restored, forests again covered the land, herds dotted its pastures, fishes peopled the waters, and fine sediments abounding in forms of life accumulated in new sheets above the strata of cooled lava. The banks of the Des Chutes River and Columbia afford splendid sections of these lake deposits, where the history I have so hastily sketched may be read as from an open book.

But, it will be said that there are portions of the great central plateau which have not been drained in the manner I have described. For, here are basins which have no outlets, and which still hold sheets of water of greater or less area, such as those of Pyramid Lake, Salt Lake, etc. The history of these basins is very different from that of those already mentioned and not less interesting nor easily read. By the complete drainage of the northern and southern thirds of the plateau through the channels of the Columbia and Colorado, the water surface of this great area was reduced to the tenth or hundreth part of the space it previously occupied. Hence, the moisture suspended in the atmosphere was diminished in like degree, and the dry hot air, sweeping over the plains, licked up the water from the undrained lakes until they were reduced to their present dimen-

sions. Now, as formerly, they receive the constant flow of the streams that drain into them from the mountains on the east and west. But the evaporation is so rapid that their dimensions are not only not increased thereby, but are steadily diminishing from year to year. Around many of these lakes, as Salt Lake, for example, just as around the margins of the old drained lakes, we can trace former shore lines and measure the depression of the water level. Many of these lakes of the Great Basin have been completely dried up by evaporation, and now their places are marked by alkaline plains or "salt flats." Others exist as lakes only during a portion of the year, and in the dry season are represented by sheets of glittering salt. Even those that remain as lakes are necessarily salt, as they are but great evaporating pans where the drainage from the mountains—which always contains a portion of saline matter—is concentrated by the sun and wind until it becomes a saturated solution and deposits its surplus salts upon the bottom.

The southern portion of the great central table land—that which has been denominated the Colorado Plateau—is almost without mountain barriers or local basins, and we, therefore, find upon it fewer traces of ancient lakes, though they are not entirely wanting. It is apparent, however, that this high plateau, which stretches away for several hundred miles west of the Rocky Mountains, was once a beautiful and fertile district. The Colorado draining then, as now, the western ranges of the Rocky Mountains, spread over the surface of this plateau, enriching and vivifying all parts of it. When it reached the western margin of the table land, however, it poured over a precipice or slope 5,000 feet in height, into the Gulf of California, which then reached several hundred miles further north than now. In process of time the power developed by this stupendous fall cut away the rock beneath the flowing water, and formed that remarkable gorge to which I have already referred. This gorge is nearly 1,000 miles in length and from 3,000 to 6,000 feet in depth, and is cut through all the series of sedimentary rocks from the Tertiary to the Granite, and has worn out the granite to a depth of from 600 to 800 feet. Just in proportion as the Colorado deepened its channel, the region bordering it became more dry, until ultimately the drainage from the mountains passed through it, in what may be even termed underground channels, and contributed almost nothing to the moisture of the surrounding country. The reason why the walls of this cañon stand up in

such awful precipices of thousands of feet is, that the perennial flow of the stream is derived from far distant mountains; almost no rain falls upon its banks, and when any portion of the bordering cliff has passed beyond the reach of the stream, it stands almost unaffected by atmospheric influences.

On the east of the Rocky Mountains lies the country of the "plains," a region not unlike in its topography to the great plateau of the west, but differing in this, that it is not bordered on the east by a continuous mountain chain; that it slopes gently downward to the Mississippi, and that its eastern half has been so well watered that its valleys have been made broad and all its topographical features softened down. In former times, however, the topographical unity now conspicuous on the plains did not exist, and the surface was marked by a series of great basins which received the flow of water from the Rocky Mountains and formed lakes, less numerous it is true, but of greater extent than those of the far West. The northern portion of the eastern plateau has been Dr. Hayden's chosen field of exploration for many years; a field he has well tilled, and from which he has obtained a harvest of scientific truth which will form for him an enduring and enviable monument.

Among the most interesting researches of Dr. Hayden in this region, are the studies he has made of the deposits which have accumulated in these great fresh-water basins. The story he has written of his explorations of this district has been so well and fully told that I shall not attempt to review it. Suffice it to say, that the series of fresh-water basins discovered by Dr. Hayden in the country bordering the Upper Missouri have proved to be as rich in new and interesting forms of animal and vegetable life as any that have been found upon the earth's surface. The vertebrate remains collected by Dr. Hayden have been carefully studied, fully described and illustrated by Dr. Leidy, and the splendid monograph which he has published of these fossils, forms a contribution to paleontology not second in value or interest to that made by Cuvier in his illustrations of the fossils from the Paris basin; nor to that of Falconer and Cautley, descriptive of the fossils of the Sewalik hills of India.

The scarcely less voluminous and interesting collections of fossil plants made by Dr. Hayden have been placed in my hands for examination. Of these, the first instalments were described and drawn some years since as a contribution to the report of Colonel W. F. Raynolds,

U.S.A., a report not yet published by the Government. The descriptions, however, were printed in the annals of the Lyceum of Natural History of New York, vol. 9, 1868.

The general conclusions drawn from a study of this portion of Dr. Hayden's collections as regards the floras of the Tertiary and Cretaceous periods, the topography and climate of the interior of the continent,—and which form a part of my contribution to Colonel Raynold's report,—will be found quoted on another page. Since that report was written, very large additions have been made to our knowledge of our later extinct floras, by collections of fossil plants made in different portions of the western part of our continent by Dr. Hayden, Mr. Condon, Dr. Le Conte and myself; and also by the collections made by Mr. W. H. Dall and Captain Howard in Alaska, and by several explorers on the continent of Greenland.

Deferring for the present a comparison of the plants derived from strata of similar age in these widely separated localities and the inferences deducible from them as regards the physical geography of our continent, I should say that the flora and fauna of the lake deposits on both sides of the Rocky Mountains apparently belong to one and the same geological age, and tell the same story in regard to the topography, climate, conditions and development of animal and vegetable life. There is this striking difference however, perceptible at the first glance between the fresh-water Tertiaries of the east and west. In Oregon, Idaho and Nevada, volcanic materials have accumulated in the lake basins to a much greater extent than east of the Rocky Mountains; and we have abundant evidence that during the Tertiary period the western margin of the continent was the scene of far greater volcanic activity than we have any record of in the Rocky Mountain belt.

The deposits formed by the lake basins of the Upper Missouri region are shales, marls and earthy limestones, with immense quantities of lignite, but with almost no traces of volcanic products. The number of fossil plants and animals is much greater there than further west; and we have in these deposits proof that during unnumbered ages this portion of the continent exhibited a diversified and beautiful surface, which sustained a luxuriant growth of vegetation and an amount of animal life far in excess of what it has done in modern times. This condition of things existed long enough for hundreds and even thousands of feet of sediments

to accumulate in the bottoms of extensive fresh-water lakes. These lakes were gradually and slowly diminished in area by the filling up of their basins and by the wearing away of the barriers over which passed their gently flowing, draining streams. Since the deposition of the fresh-water Tertiaries which occupy the places of the old lakes, great changes have taken place in the topography of this region by the upheaval of portions of the Rocky Mountain ranges. In some localities these lake deposits are found turned up on edge and resting on the flanks of the mountains which border the plains on the west. It is certain, however, that much of the Rocky Mountain belt existed anterior to this date. We have in these, and many other facts that might be cited, proofs of the truth of the assertion I have elsewhere made that these great mountain chains, though existing at least in embryo from the earliest paleozoic ages, have, since then, been subject to many and varied modifications; that they have been, in fact, hinges upon which the great plates of the continent have turned; lines of weakness where the changes of level experienced by the continent have been most sensibly felt.

It is a somewhat remarkable fact that the collections of fossil plants made by Dr. Hayden from different localities differ so much among themselves. In every newly discovered plant-bed he has obtained more or less species of which we before had no knowledge, and it is even true that between some of his collections there are no connecting links. It is also true that much of the material he has collected has not yet received the study it needs. From these facts it will be seen that much yet remains to be done before the great interval of time during which this series of fresh-water Tertiaries accumulated can be divided into definite periods, and before we can venture to affirm that such an epoch had a flora of such or such a botanical character and, therefore, this or that average annual temperature. Some interesting facts came out, however, at once in the examination of these materials; to these I will briefly refer.

In the beginning of the Cretaceous age, North America, as we learn, presented a broad land surface, having a climate similar to the present, and covered with forests consisting, for the most part, of trees belonging to the same genera with those that now flourish upon it. In the progress of the Cretaceous age, the greater part of the continent west of the Mississippi sank beneath the ocean, and the deposits made during the later portions of the Cretaceous age contain a vegetation more tropical in

character than that which had preceded it. It seems probable that at this time the lands which existed as such, west of the Mississippi, were islands of limited extent, washed by the gulf stream, which apparently had then a course north and west from the Gulf of Mexico to the Arctic Sea.

The earlier Tertiary epochs were, however, marked by an emergence of the continent and a gradual approach to previous and present conditions. This is indicated by the fact that the oldest Tertiary deposits (Eocene?) contain a flora less like the present than is that of the Miocene or Middle Tertiary. In this category of older deposits with a more tropical flora, I would place the Green River Tertiary beds, those of Mississippi studied by Lesquereux, and those of Brandon, Vermont.

In the Miocene age, the continental surface was broader, the lake-basins of the West contained only fresh water, and the land surface was covered with a vegetation very much like that of the present day, a number of Miocene species still existing. The climate of the continent in the Miocene age was much milder than now. Fan-palms then grew as far north as the Yellowstone River, and a flora flourished in Alaska and on Greenland as varied and as luxuriant as now grows along the fortieth parallel. At this time there must have been some sort of land connection between our continent and Europe on the one hand and Asia on the other. The flora of all these regions was essentially the same, and a large number of plants were common to the three continents. In this age, the mammalian fauna of our continent exhibited the same remarkable development that it did in Europe and Asia; and over our Western plains roved herds of great quadrupeds, rivaling in number and variety those that have struck with wonder and surprise every traveler in South Africa.

This state of things seems to have continued through the Pliocene age and up to the time when the climate of the continent was completely revolutionized by the advent of the "Ice period." The change which took place at that time was such as taxes the imagination to conceive of as much as it taxes the reasoning powers to account for.

We have seen that in the Middle Tertiary age the climate of Alaska and Greenland was that of New York and St. Louis at present. In the next succeeding period, the glacial epoch, the present climate of Greenland was brought down to New York, and all the northern portion of the continent wrapped in ice and snow. This change was undoubtedly gradual (for nature does not often "turn a corner"), but it is plain that

it must have resulted in the gradual driving southward of all the varied forms of animal and vegetable life that were spread over the continent to the Arctic Sea. When glaciers reached as far south as the fortieth parallel it is evident that a cold-temperate climate prevailed in Mexico, and that only in the south of Mexico would the average annual temperature have been what it was previously in the latitude of New York. We must conclude, therefore, that the herds of mammals which once covered the plains of the interior of North America were forced by the advancing cold into such narrow limits in Southern Mexico that nearly all were exterminated. Plants bore their expatriation better; inasmuch as a tree, even of the most gigantic size, will live upon the space occupied by its roots provided the climatic conditions are favorable; while one of the larger mammals would require at least a thousand times this space for its support. As a consequence, we find the present flora of our continent much more like that of the Miocene than is our fauna, though the change to which I have referred seems to have been fatal to quite a number of the most abundant and interesting of our Miocene forest trees. Of these, the *Glyptostrobus* may be taken as an example. This was a beautiful conifer which, in Miocene times, grew all over our continent and over Northern Europe. In the change to the glacial period, however, it was exterminated, both there and here, yet continued to exist in China—where a Miocene colony from America had taken root—and it is growing there at the present time. This great ice-wedge which came down from the north, separated very widely many elements in our Miocene flora which have never since been re-united, so that when the storm had passed and better days had come, and the Mississippi Valley and Atlantic States were re-possessed by the descendants of the Tertiary plants, they were still separated, by many thousand miles, from their brethren which had formerly crossed the now submerged bridge of Behring's Straits; and thus the two kindreds have been growing, and flowering, and seeding, and dying in each colony far beyond the reach of the other and developing their peculiarities each in its own way from generation to generation. When now we come to compare the present flora of China and Japan with that of the eastern half of our continent, we find the strongest proofs of their intimate relationship. Many of the species are identical, while others are but slightly changed and, on the whole, the differences are less than such as have grown out of separation in human kindred colonies in an infinitely shorter period.

Among the great mammals that formerly inhabited our continent but such as are now extinct, there were some which seem to have bid defiance to the changes I have detailed. These were particularly the mastodon and elephant, both of which were probably capable of enduring great severity of climate. The mammoth, we know, was well defended from the cold by a thick coat of hair and wool, and was probably capable of enduring a degree of cold as severe as that in which the musk-ox now lives. We know that both these great monsters—the elephant and mastodon—continued to inhabit the interior of our continent long after the glaciers had retreated beyond the upper lakes, and when the minutest details of surface topography were the same as now. This is proven by the fact that we not unfrequently find them embedded in peat in marshes which are still marshes, where they have been mired and suffocated. It is even claimed that here, as on the European continent, man was a cotemporary of the mammoth, and that here as there, he contributed largely to its final extinction. On this point, however, more and better evidence than any yet obtained is necessary, before we can consider the cotemporaneity of man and the elephant in America as proven. The wanting proof may be obtained to-morrow, but to-day we are without it.

The pictures which geology holds up to our view of North America during the Tertiary ages, are in all respects but one, more attractive and interesting than could be drawn from its present aspects. Then a warm and genial climate prevailed from the Gulf to the Arctic Sea; the Canadian highlands were higher, but the Rocky Mountains lower and less broad. Most of the continent exhibited an undulating surface, rounded hills and broad valleys covered with forests grander than any of the present day, or wide expanses of rich savannah over which roamed countless herds of animals, many of gigantic size, of which our present meager fauna retains but a few dwarfed representatives. Noble rivers flowed through plains and valleys, and sea-like lakes broader and more numerous than those the continent now bears, diversified the scenery. Through unnumbered ages the seasons ran their ceaseless course, the sun rose and set, moons waxed and waned over this fair land, but no human eye was there to mark its beauty, nor human intellect to control and use its exuberant fertility. Flowers opened their many-colored petals on meadow and hill-side, and filled the air with their perfumes, but only for the

delectation of the wandering bee. Fruits ripened in the sun, but there was no *hand* there to pluck, nor any speaking tongue to taste. Birds sang in the trees, but for no ears but their own. The surface of lake or river was whitened by no sail, nor furrowed by any prow but the breast of the water-fowl; and the far-reaching shores echoed no sound but the dash of the waves, and the lowing of the herds that slaked their thirst in the crystal waters.

Life and beauty were everywhere, and man, the great destroyer, had not yet come, but not all was peace and harmony in this Arcadia. The forces of nature are always at war, and redundant life compels abundant death. The innumerable species of animals and plants had each its hereditary enemy, and the struggle of life was so sharp and bitter, that in the lapse of ages many genera and species were blotted out forever.

The herds of herbivores—which included all the genera now living on the earth's surface, with many strange forms long since extinct—formed the prey of carnivores commensurate to these in power and numbers. The coo of the dove and the whistle of the quail were answered by the scream of the eagle, and the lowing of herds and the bleating of flocks come to the ear of the imagination, mingled with the roar of the lion, the howl of the wolf, and the despairing cry of the victim. Yielding to the slow-acting but irresistible forces of nature, each in succession of these various animal forms has disappeared till all have passed away or been changed to their modern representatives, while the country they inhabited, by the upheaval of its mountains, the deepening of its valleys, the filling and draining of its great lakes has become what it is.

These changes which I have reviewed in an hour seem like the swiftly consecutive pictures of the phantasmagoria or the shifting scenes of the drama, but the æons of time in which they were effected are simply infinite and incomprehensible to us. We have no reason to suppose that *terra firma* was less firm, or that the order of nature in which no change is recorded within the historic period, was less constant then than now. At the present rate of change—throwing out man's influence—a period infinite to us would be required to revolutionize the climate, flora and fauna, but there is no evidence that changes were more rapid during the Tertiary ages.

Every day sees something taken from the rocky barrier of Niagara; and, geologically speaking, at no remote time our great lakes will have

shared the fate of those that once existed at the far West. Already they have been reduced to less than half their former area, and the water level has been depressed 300 feet or more. This process is pretty sure to go on until they are completely emptied.

The cities that now stand upon their banks will, ere that time, have grown colossal in size, then gray with age, then have fallen into decadence and their sites be long forgotten, but in the sediments that are now accumulating in these lake-basins will lie many a wreck and skeleton, tree-trunk and floated leaf. Near the city sites and old river mouths these sediments will be full of relics that will illustrate and explain the mingled comedy and tragedy of human life. These relics the geologist of the future will doubtless gather and study and moralize over, as we do the records of the Tertiary ages. Doubtless he will be taught the same lesson we are, that human life is infinitely short, and human achievement utterly insignificant. Let us hope that this future man, purer in morals and clearer in intellect than we, may find as much to admire in the records of this first epoch of the reign of man, as we do in those of the reign of mammals.

PHOTOGRAPHS.

GRANITE ROCK

Buford Station, Laramie Mountains.

SKULL ROCK

(Granite) Sherman Station, Laramie Mountains.

MALLOY'S CUT

Sherman Station, Laramie Range.

DIAL ROCK

Red Buttes, Laramie Plains.

LARAMIE VALLEY

From Sheepshead Mountains.

SNOW AND TIMBER LINE

Medicine Bow Mountain.

HIGH BLUFFS

Black Buttes.

BITTER CREEK VALLEY

Near Green River.

BURNING ROCK CUT

Green River Valley.

CITADEL ROCK

Green River Valley.

CASTLE ROCK

(Green River Valley.)

CHURCH BUTTES

Near Fort Bridger, Wyoming Territory.

LAKE AT THE HEAD OF BEAR RIVER

Uintah Mountains.

CONGLOMERATE PEAKS OF ECHO

SENTINEL ROCK

Echo Cañon.

HANGING ROCK

Echo City.

COALVILLE

Weber Valley, Utah.

THOUSAND MILE TREE

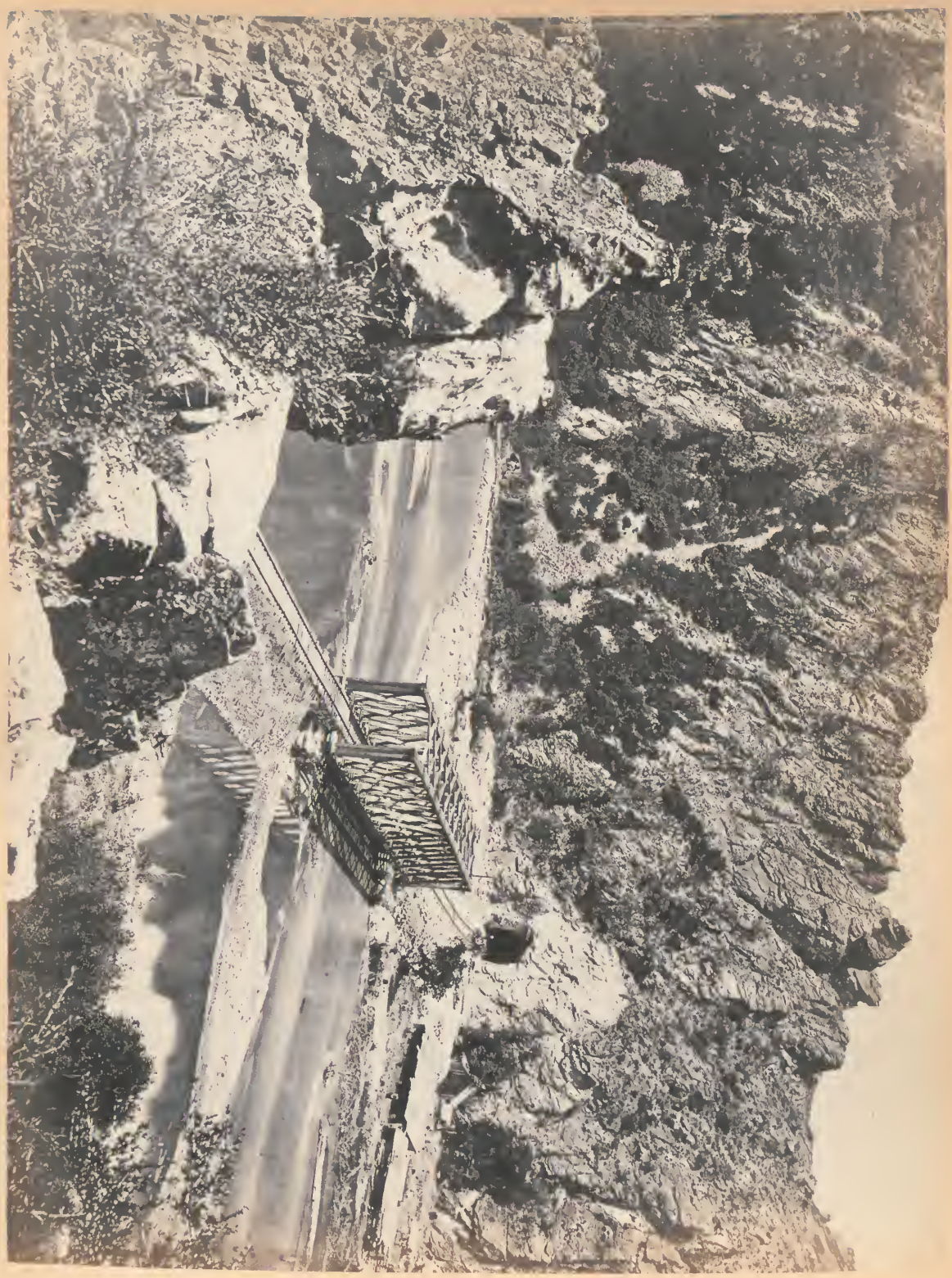
Wilhelmina's Pass.

WILHELMINA'S PASS

Distant view of Serrated Rocks or Devil's Slide, Weber Cañon, Utah.

SERRATED ROCKS OR DEVIL'S SLIDE

(Near view)—Weber Cañon, Utah.



TUNNEL NO. 3.

Weber Canon, Utah.

DEVIL'S GATE

(From below) Weber Cañon, Wasatch Mountains.

CITY CREEK CANON

Wasatch Mountains, Salt Lake Valley.

WASATCH RANGE OF ROCKY MOUNTAINS

From Brigham Young's Woolen Mills.

SALT LAKE CITY

Camp Douglas and Wasatch Mountains in the background.

GREAT MORMON TABERNACLE

Salt Lake City.

TRESTLE WORK

Promontory Point, Salt Lake Valley.

SUMMIT OF SIERRA NEVADA

Snow Sheds in foreground, Donner Lake in the distance, C. P. R. R.

HYDRAULIC GOLD MINING

Near Dutch Flats, California, C. P. R. R.